Vernon

SCIENTIFIC AMERICAN SUPPLEMENT. No. 1485

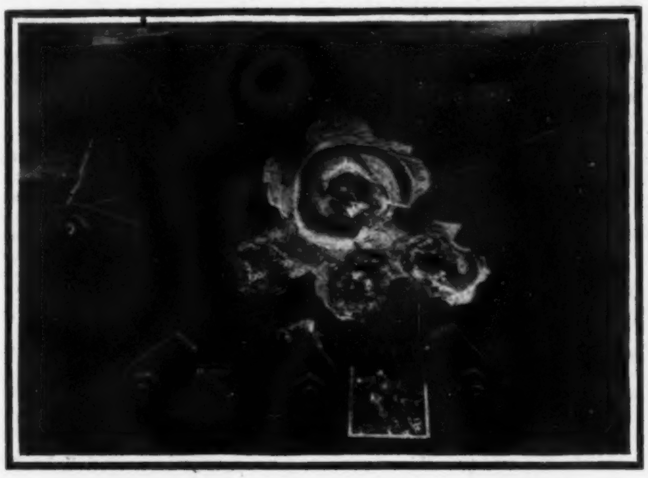
Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1904, by Munn & Co.

Scientific American, established 1845.
Scientific American Supplement, Vol. LVII., No. 1485.

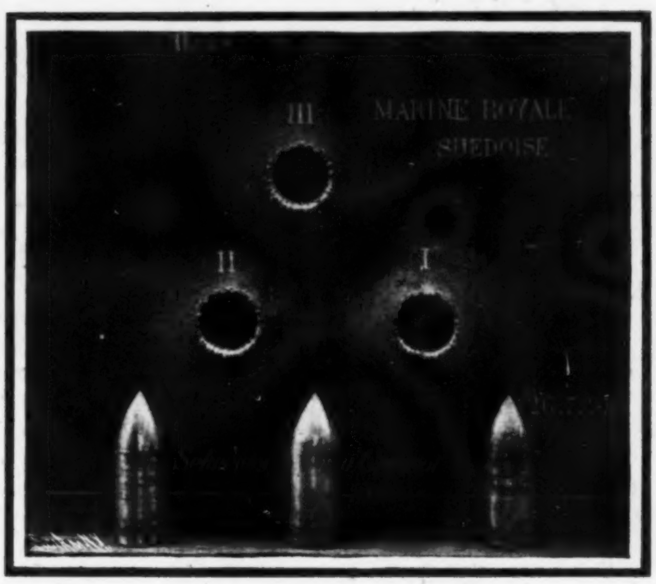
NEW YORK, JUNE 18, 1904.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

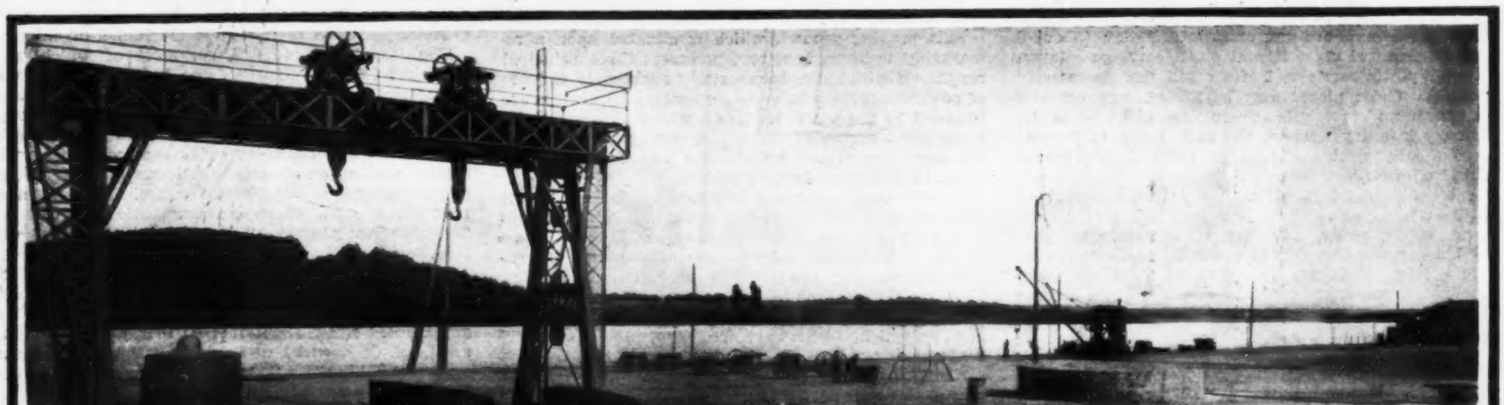
THE PROVING GROUNDS AT HARFLEUR, FRANCE.



RESULT OF FOUR SHOTS FIRED AT A CREUSOT PLATE.



A COMPLETELY PERFORATED PLATE.



THE CREUSOT PROVING GROUNDS AT VILLEDIEU.

CREUSOT AND THE ORDNANCE MADE THERE.

CREUSOT AND THE ORDNANCE MADE THERE.*

By L. Ramakers.

One of the largest establishments for the manufacture of war material is that of Messrs. Schneider & Co. at Creusot, France. It was the Schneider guns which enabled Boers to offer such a sturdy resistance to the English in the last war in the Transvaal. As a proof of this, we have only to cite some passages from the London Times of the 26th and 28th of December, 1899: "The Boers have obtained the latest type of ordnance, compared with which the English guns are antique. . . . It is absolutely evident that if the English gunners had occupied the same position as the Boers, and been provided with the same weapons possessed by the Boers, viz., guns constructed by Messrs. Schneider & Co., the loss in men and property at Ladysmith would have been ten times as great."

The foundries of Creusot have furnished also the greater part of the ordnance both for Russia and Japan, and for this reason this establishment possesses great interest at the present time.

The Creusot works turn out all sorts of large metal work, but more particularly do they devote their energies to the making of ordnance and armor plating, a branch which has become a specialty since the war of 1870. The establishment carries upon its rolls about 18,000 employes. The foundries and machine shops devoted to ordnance alone cover a superficial area of 30,000 square meters, and extend to a length of four kilometers without interruption.

Modern cannon are divided as follows:

1. According to their type; guns of standard length, medium howitzers or shell guns, and short guns or mortars.

2. According to their caliber; in great guns of 10 to 50 centimeters bore, or medium guns of 6 to 10 centimeters, or small guns of from 25 to 50 millimeters bore.

3. According to their rapidity of fire; into ordinary guns, rapid-fire guns, and automatic guns and mitrailleuses or multiple cannon.

PROVING GROUNDS AT HARFLEUR.

CREUSOT AND THE ORDNANCE MADE THERE.

4. According to their purpose; for ships, for fortresses, for the field or mountain guns.

Among the cannon made at Creusot we shall glance at the principal types, and among them particularly those called rapid-fire guns. Since the advent of smokeless powder, all the manufacturers have striven to increase the rapidity of fire, which is now no longer restricted by the clouds of smoke issuing from the mouths of the pieces, and which had to become dissipated before the gun could be trained again.

The naval rapid-fire gun of 15 centimeters (about 6 inches), mounted upon a front pintle carriage or upon a center pintle carriage, has a recoil that is scarcely sensible. These pieces may be loaded very quickly, the charge and projectile forming one piece, as in the ordinary infantry weapon, the shell being in general automatically ejected. These guns are usually placed behind a metallic shield.

Another type of rapid-fire gun is a cannon of 47 millimeters bore and 60 calibers length, built for automatic loading. Its recoil is entirely overcome, the gunner holding his shoulder to the butt, and sighting as with a rifle. This gun is capable of rapid manipulation, and is much employed by armored ships against the torpedo craft; it is in fact the only defense it has against these small but terrible adversaries.

The Creusot works recently furnished the Servian government with a series of very remarkable guns. These guns have been built for transportation over all sorts of road or country, and at any marching speed.

Before delivery, all pieces of ordnance built at the Creusot works are tested for every requirement. For this purpose Schneider & Co. control a proving ground at La Villedieu near Creusot and a field for long-range target practice at Harfleur near Havre. The proving grounds at La Villedieu afford facilities for testing military material of any power whatever, and in all possible manners; be it for its ballistic properties, its resistance, or its action in the most varied cases and conditions. In the interest of such tests a number of heavy timber platforms have been erected, upon which are placed the pieces to be tested. This is of course to prevent the cannon from gradually embedding themselves in the ground from the force of the recoils, as well as to facilitate bringing the gun again into the same position for firing. From these bases it is possible to shoot into beds of sand 22 to 32 feet thick, from any desired angle of elevation. With the aid of telescopes or strong field glasses, it is possible to note from the observatory the result of each discharge upon the butts, and observe just how the material behaves under conditions similar to those in actual conflict. Shooting into the sand bed is done with a view to ascertaining the muzzle velocity of the projectile. For this purpose, two velocity frames are interposed between the piece and the sand bed in the path of the projectile. As the latter passes through them, it breaks some of the wires and interrupts the electric current with which they are charged, and which is in turn connected with the apparatus for measuring and registering the instant of passage of the projectile. The time required for the projectile to cover the distance between the two is called the initial or muzzle velocity of the projectile.

The proving grounds are provided with the most approved instruments for obtaining all desirable data, such as electric chronographs, crushers for measuring the pressures in the piece, registering gages for showing the pressures in the check cylinders, speedometers for measuring the movement of the recoil from the carriage, etc. Thus it is possible to obtain exact information concerning the functioning details of the carriage, whether the projectile be shot into the sand bank or into the sea.

The proving ground is laid out in such a manner that all these tests may be carried out with the greatest safety possible. A system of mirrors affords complete observation of all the effects of the shot. The gun is fired from a distance, either with an electric primer, or with the ordinary lanyard and primer.

The long-range testing grounds at Harfleur form a natural complement to the ordnance establishment of Messrs. Schneider & Co.

The field is situated upon a terrain which extends over a distance of 13½ miles in length, and is laid out in such a manner as to allow of carrying out, under the best conditions, all the experiments in ballistics necessary for a range of from 3¾ to 5 miles.

It serves especially:

1. For the establishing of range tables for different materials.

2. For experiments in precision at great distances, notably for field, siege, or fortress guns.

3. For discharges with powerful explosives.

4. And for the study of experimental fuses.

This proving ground, which is situated upon a remarkably uniform territory, possesses three principal ranges, of which one is especially adapted to the use of powerful explosives, since its limits on the south are bounded by the sea shore itself, which at low tide exposes considerable extent of dry land, that lends all the more securely, and under the best possible conditions, to this sort of gun practice.

Within the proving grounds annexed to the Creusot establishment are tested the Schneider armor plates for turrets and the sheathing of ships. Here they are forced to withstand the energies of the different engines of war they are likely to meet in actual service. This is a fitting place to make a few remarks upon the Schneider plate. We recall that after the war of secession, in which the first armored ship, the "Merrimac," made its appearance, the attention of metallurgists was seriously attracted toward the manufacture of armor plates. Messrs. Schneider were among the first to appreciate the importance of this branch of the founder's business, and immediately devoted a part of their activity to it, soon acquiring considerable repute in this specialty.

Thanks to the powerful machines at the disposal of Schneider & Co., among which we have only to cite the great press for compressing liquid steel under a force of 10,000 tons, the Creusot works are able to make armor plate 23.62 inches thick and weighing 65 tons. They have already delivered to the various naval departments about 80,000 tons of these plates. France alone has ordered about 36,000 tons of them, and the difference has been parceled out to almost every naval establishment of the world.

The plates are alloyed with different metals, such as nickel, cobalt, etc., which confer upon them enormous resisting powers. Armor plates made twenty-five years ago are pierced without the slightest difficulty by the projectiles of the present day.

To-day, thanks to a specially tempered steel which is one of the secrets of manufacture, the works at Creusot are turning out plates upon which the modern shells fired from the large guns of the day have but small effect.

* Specially prepared for the Scientific American Supplement.

SUPERHEATED STEAM.*

By F. J. Rowan.

Superheated steam offers a most interesting subject for study, whether it is considered from the abstract and theoretic side or from the concrete and practical side.

With the former are connected the thermo-dynamic propositions and calculations which assume a perfectly gaseous condition for superheated steam, and deduce its efficiency accordingly. This view of the subject is fully dealt with in Rankine's "Steam Engine and Other Prime Movers," in Prof. R. H. Thurston's "Superheated Steam" (Amer. Soc. Mech. Eng., vol. xvii.), and in Peabody's "Thermo-dynamics of the Steam Engine." The literature devoted to the practical side of the subject is voluminous, and contains the history of, the various attempts to introduce the use of superheated steam, with the failures of the early and the successes of the later forms of apparatus.

HISTORICAL.

Although the "flash" boilers, which date from that of John Payne, in 1736, undoubtedly produced steam which was more or less superheated, necessarily on account of the method of steam production adopted in these boilers, yet the design of Sir William Congreve, in 1821, was perhaps the earliest attempt to treat steam after its formation in a boiler, his object having been "to increase its volume." It is not likely that the importance of increasing its temperature would be recognized at so early a date.

The system invented by Jacob Perkins, in 1822, was also, in one aspect of it, a method of producing superheated steam, although the degree of superheat was probably small. In this case the water in the boiler was heated to 400 deg. or 500 deg. F. without allowing steam to form, the boiler being quite full of water. When a small additional quantity of water was then forced into the boiler by a pump, a corresponding quantity of the superheated water escaped by a valve into a steam pipe, where it instantly flashed into steam.

French writers (such as M. Maurice Miet, in Le Génie Civil) mention that the superheating apparatus was designed by Becker (in 1827), Trevithick (in 1828 or 1832)†, Raffard‡ (in 1848), de Quillac (in 1849), Moncheul (in 1850), and by Hirn (in 1855); but, except in the case of the last of these, no permanent benefits seem to have been secured. Trevithick reported, in 1828, on the engines of the Brinner Downs Mine in Cornwall, where the steam pipes and cylinders had been inclosed in brick-built flues, with a fire-grate conveniently attached, in order by heating them up to prevent condensation. The idea was merely to make a better non-conducting covering than that of the sawdust used at a neighboring mine, but unexpected economy was realized, the duty of the engine having been increased from 41 to 63 million foot-pounds per bushel (84 pounds) of coal. When the superheating flues consumed 5 bushels of coal per 24 hours, the steam boiler required 67 bushels, which quantity became 108 bushels when the superheating was not employed, this showing a saving of 33.4 per cent.

The boiler, which Trevithick patented in 1832, was composed of vertical water tubes set in a circle, and joined to an annular chamber at top and bottom; the superheater pipes were U-shaped, dependent over the fire, with all joints in the upper part of the boiler and clear of the fire gases, which were led off into the cylinder jacket on their way to the funnel or chimney.

The investigations of Hirn, most of which were published in the Bulletin of the Industrial Society of Mulhouse, or in that of the Alsatian Society of Steam Users, have been the means of encouraging the engineers of Alsace and the adjoining country, so that at the present day Germany holds the lead in the successful application of numerous forms of superheaters, and in the use of superheated steam. Hirn patented, in 1855, a form of superheater which he called a "hyper-thermo-generator," formed principally of cast iron.

The late Mr. John Penn (Proceedings Inst. Mech. Eng., 1859) ascribed his knowledge of the subject to Mr. Thomas Howard, of Rotherhithe, who had tried superheated steam about 1831 or 1832, and to Dr. Haycraft, of Greenwich, who had taken up the subject after Mr. Howard. It is, however, stated elsewhere that as early as 1831 Dr. Henry Haycraft himself obtained a patent for superheated steam, and believed that he had discovered a power ten times greater than ordinary steam.

In 1849 Mr. James Frost, of Brooklyn, N. Y., communicated a paper to the Rumford Committee of Cambridge University, in which he claimed that he had increased the power of steam four to six times, and that at 650 deg. F. a change took place, a new vapor, which he called "stame," being formed. This was subsequently proved to be merely perfectly dry steam or "steam gas," but the term "stame" was used for some years in controversies which arose in technical

* Read before Institution of Engineers and Shipbuilders.

† Spineux (in 1840) [see Engineering, 14th Feb, 1890, p. 174].

‡ See also Prof. R. H. Thurston on Superheated Steam, Trans. Am. Soc. Mech. Eng., vol. xvii., p. 490.

journals. The Committee of the University reported unfavorably on Mr. Frost's claims, but several experimenters corroborated his statements by results obtained at a subsequent date.

The subject was investigated by Mr. B. F. Isherwood in 1854, 1860, and in 1862-64, and his results were published in the Journal of the Franklin Institute (vol. xxvii., third series) in his "Experimental Researches" (vols. i. and ii.), and in the official reports of the United States government. The first experiments were made with the Wethered system of using a mixture of saturated and "surcharged" steam; the second with Waterman's apparatus, which consisted of a steam jacket around a steam supply valve, connected with a superheating arrangement when desired, and also a peculiar throttle valve. This plan was arranged for "the steam to heat itself by means of the differences of temperature due to differences of pressure produced by the use of a simple throttle valve." This was evidently a plan to produce the small amount of superheating derived from wire-drawing the steam, and it proved abortive in these experiments, even with the steam jacket, because "so great were the refrigerating influences in the cylinder that an adheating of 31.7 degrees possessed by the steam on entering the valve chest, obtained by the Waterman system of throttling, was inadequate to the production of any net gain in the cost of power." The experiments undertaken for the United States government were more varied and were carried out principally in steamers or marine engines and to much higher temperatures than had formerly been used.

Messrs. C., J., and S. Wethered, who were large woolen manufacturers in Baltimore, U. S. A., had been experimenting for some time before they applied for a patent, in May, 1853, for the employment of a mixture of superheated with saturated steam in the cylinders of steam engines. Their superheater consisted of a pipe led from the steam space of the boiler at the upper part and near the rear end, and continued in a coil in the combustion space directly over the fire and in the heating flues. This superheater had about three square feet of surface per nominal horse-power. Mr. Wethered laid great stress upon his employing two steam pipes, and reckoned that the admixture of saturated with superheated steam preserved the cylinder and valve surfaces, while giving the benefit of superheat. (See Min. Proc. Inst. C. E., 1860, vol. xix., p. 462*; and Trans. Inst. Mech Eng., January, 1860, p. 8.) This apparatus was in different forms tried in the P. and O. Company's steamers, in H. M. S. "Dee," and in the Admiralty yacht "Black Eagle," with good results. An apparatus on similar lines was said to have been supplied by Messrs. Boulton & Watt to the steamer "Great Eastern" about the year 1862 ("Bourne on the Steam Engine," p. 242), but this does not clearly appear from the illustrations given by Bourne. Although excellent results were obtained in several instances of the use of Messrs. Wethered's plan, it was proved that a mixture of ordinary with superheated steam was unnecessary, because the mean temperature arrived at was precisely that of moderately superheated steam alone. The effects of the Wethereds' mixture could be obtained when a temperature of not over 369 deg. F. was employed in the superheated steam. Experiments made by Mr. Isherwood with the Wethereds' plan in New York, in 1853, were, however, the means of spreading the belief that the presence of the saturated steam provided a lubricating quality, which was absent from unmixed superheated steam. (Journal of the Franklin Inst., vol. xxvii., third series, pp. 257-261.) Consequently several patents were taken out in America for modifications of the Wethered plan by Cornell (1867), Stone (1859-1860), Brown & Gregg (1865), and Carvalho (1860). Carvalho's patent aimed at preventing the action on certain qualities of iron which had been noticed in steam engines, and had been ascribed to the decomposition of the superheated steam at high temperature. Such action was, however, more likely to occur in the pipes or tubes employed as superheaters, and subjected to the high temperatures of the flame or hot gases in the combustion chamber or flues in which the superheaters were placed, and the deterioration of the metal surfaces of cylinders and slide valves and faces must be ascribed to other causes.

Bourne, in his "Treatise on the Steam Engine," describes the superheaters constructed by R. Napier & Sons, Lamb & Summers, W. Beardmore, and Thos. Richardson & Sons, the last having been designed by G. W. Jaffrey; and in a paper by Mr. John N. Ryder to the Institution of Mechanical Engineers (Proceedings, January, 1860), there are descriptions of the superheaters of Parson & Pilgrim and of D. Patridge, with some account of their action.

The papers by Mr. William Patchell (in Proc. Inst. Mech. Engineers, April, 1896), and by Prof. William Ripper (in Min. Proc. Inst. C. E., vol. cxxviii., May, 1897, p. 60) are among the earliest of those which deal with the more recent practice in the use of superheated steam, and may be said to mark the period of the revival of any great degree of interest in it as far as this country is concerned. Prof. R. H. Thurston's able treatise on the same subject ("Superheated Steam: Facts, Data, and Principles Relating to the Problem") in Transactions of the American Society of Mechanical Engineers (vol. xvii., p. 488), which was read in May, 1896, is another prominent landmark in connection with it. From that time onward the Minutes of Proceedings of the Institute of Civil Engineers are seldom without records of investigations made on the continent of Europe with different forms of steam superheaters, and many papers have appeared elsewhere.

DESIGNS OF SUPERHEATERS.

The e... forms of superheaters used in this country were placed above the boiler at the base of the funnel in the case of marine boilers, with which they were almost exclusively used. One of the earliest was that introduced by John Penn & Son, in the P. and O. Company's steamer "Valetta" (see Trans. Inst. Mech. Eng., 1859, p. 195). The engines were of 260 nominal horsepower, and the boilers were of Lamb & Summers's design, the superheaters being placed in the uptake outside the ends of the vertical flues, which in Lamb's arrangement took the place of horizontal flue tubes. Two horizontal faggots of wrought-iron tubes, 2 inches diameter inside and 6 feet 3 inches long, formed the superheater, each bundle consisting of 44 tubes. They were placed in vertical rows, with clear spaces between the rows horizontally for allowing access in cleaning the boiler flues. The tubes were fixed into three flat chambers made of wrought iron welded up at the corners, and closed each with a single flange joint. The steam from the boiler entered the center chamber through a stop valve, and was taken off from the end chambers by other stop valves communicating with the steam pipes to the engine. The total area of superheating surface, including the wrought-iron chambers, was 374 square feet in each of the two boilers. The pressure of steam then used was 20 pounds per square inch, and the steam was superheated 100 degs., or from 260 degs. up to 360 or 370 degs. F.

Patridge's superheater consisted of a cylinder filled with vertical tubes, placed vertically over the uptake, and resting on the steam chest at the base of the chimney (see Trans. Inst. Mech. Eng., 1860, p. 25). The furnace gases passed up through the tubes and through an annular space surrounding the cylinder between it and the chimney, and the steam was passed across the cylinder and over a vertical baffle plate in the center by means of steam pipes arranged on each side at its base. This apparatus was fitted in H. M. S. "Dee," and afterward in the R. M. S. "Tyne," in the Cunard Company's steamer "Persia," and in an oblong form in the "Great Eastern."

In the case of the "Great Eastern," the superheating apparatus was constructed by Messrs. Boulton & Watt, and the oblong chambers containing the vertical tubes were placed in a casing of similar form which constituted the base of the chimney. A more simple construction was introduced by the same firm in the Holyhead steam packets. In these examples the lower part of the chimney was surrounded by a steam casing, which was divided radially by six partitions, the steam alternately ascending and descending in these until it passed over all the surface exposed to the heat from the chimney.

Messrs. R. Napier & Sons introduced into the steamer "Oleg" superheaters, consisting of horizontal steam tubes placed in an oblong casing forming the root of the funnel. The tubes were 2 inches outside diameter, 5 feet 6 inches long, and were fastened in flat stayed boxes or headers.

Messrs. Lamb & Summers employed flat-sided flues similar to those used in their marine boiler, in place of tubes, the steam being passed inside the flue passages in the superheater instead of the reverse arrangement, which was adopted in their boiler. The alternate spaces were used for passages for the chimney gases. These were 2½ inches wide, the free spaces in the steam passages being ½ inch wide. An improved form was made in 1865.

In Beardmore's superheater, horizontal steam tubes with flat headers were used, but this arrangement differed from the others, in that it formed an integral portion of the boiler, and no stop valves were employed. It was placed, like the others, in the uptake just below the chimney.

Still another arrangement similarly placed, but differing widely in design from those mentioned, was that of Jaffrey. This was made of cast iron in two different designs, one being a radial and the other a parallel arrangement of tubes and chambers.

Parson & Pilgrim's superheater, although contemporaneous with these other forms, differed from them all in having been placed in the furnaces of the marine boilers. A steam pipe common to two furnaces descended from the steam space of the boiler between the furnace doors, and branched into horizontal pipes, one of which entered each furnace below the fire bars, and passed along to near the back of the grate. Two saddle-shaped pipes then rose from horizontal pipe into the combustion space, and the steam passed through them and returned to an outgoing horizontal pipe laid at the opposite side of the ashpit from the ingoing pipe.

The arched pipes were frequently made red-hot, and it is said (Trans. Inst. Mech. Eng., 1860, p. 23) that steam of 20 pounds pressure, or 264 degs. F. temperature, was found to have attained a temperature of from 484 degs. to 540 degs. F., the pressure remaining unchanged. This apparatus was first applied to a stationary boiler at Woolwich Arsenal, and afterward to marine boilers in vessels of the Waterman's Steam Packet Company on the Thames, and in H. M. steam tug "Bustler."

Of more recent superheaters that of Schwoerer, which was derived directly from that of Hirn, has had a wide application on the Continent. It consists of cast-iron pipes, joined by semi-circular bends, so that the pipes are zig-zagged, and form flattened spirals. The pipes have longitudinal projections from the surface inside, similar to those of the Serve tube, but not so large, and have transverse ribs outside like those of radiator tubes. These pipes are placed vertically in independently-fired arrangements, and horizontally in combination with boilers of various design. This superheater has been applied to a water-tube boiler at the Grand Junction Water Works, Kew Bridge (see Engineering, 20th March, 1895, p. 403), and it is also in use at the works of Messrs. Fraser & Chalmers, Ltd., at Erith.

A former design of the Uhler superheater, recently revived in Germany, has given rise to various modifications of multi-tubular superheaters, of which one has been described by Messrs. Grouville & Arquembourg in the Genié Civil, xxiv., No. 12, p. 181.

In the Uhler, as now made, steel is used for the header, which has two divisions, from which tubes of the "Perkins" or "Field" pattern extend. It is claimed that this method of construction prevents the tubes being overheated, as the saturated steam meets the tubes at their hottest parts, and that higher temperatures and pressures can be used with this superheater; while the tubes remain more free from solid deposit.

The Hering superheater is made of tubes of small diameter of Swedish steel without welds, zig-zagged in parallel folds, the several coils passing the steam "in parallel." It has been applied to Elephant boilers and to water-tube boilers. As so arranged, the hot gases can be shut off by dampers entirely from the superheater, and made to pass over the boiler surfaces in the ordinary way. Ordinarily steam temperatures of 450 degs. to 550 degs. are attained, but temperatures as high as 800 degs. can be used.

The Gehre superheater, when fitted in a boiler flue, or as separately fired, consists of horizontal cylindrical chambers of small diameter, through which small tubes for the conduct of the hot gases pass, the steam being in the space surrounding these tubes. In the case of the Gehre arrangement adapted to a water-tube boiler, one or two rows of water-tubes are omitted, and, by means of sleeves carried through the headers, these tubes are transformed into superheating tubes, the saturated steam entering at the front and the superheated steam escaping at the back. Two tiers of these tubes are employed when a high degree of superheat is wanted.

Musgrave & Dixon's superheater consists of a row or nest of U tubes suspended from a tube plate forming the bottom of a box, and placed in the flue of a Lancashire or other boiler at the back of the furnace tubes. The box or header is divided by a vertical diaphragm so as to direct the course of the steam. By-pass and other valves are arranged, as it is not intended to pass all the steam from the boiler through the superheater. The superheater had 120 square feet heating surface, with a boiler having 1,195 square feet.

McPhail & Simpson's superheater was generally combined with an internal radiator or generator of radiating tubes placed in the interior of a boiler, the idea being to control the amount of superheat in the steam passing to the engines. This arrangement consists of two nests of vertical steel tubes expanded into cast steel headers. One of the top headers is connected to the anti-priming pipe in the boiler, and the corresponding bottom box is in connection with a copper pipe laid inside the boiler below the furnace flue. The other end of the radiator pipe connects to the second bottom box or header, and the top header of this nest to another horizontal pipe laid in the top of the boiler over the internal flue just under the water line, and ending at the main steam stop valve.

Another form of this superheater, as applied to water-tube boilers, and applications of this form of superheating tubes seem also to have been made without the radiating tubes in the water space of the drum.

Sinclair's superheater was installed by Prof. Kennedy at Edinburgh Electric Lighting Station, and various results of its working have been published. The superheater tubes are flanged and bolted to cross inlet and outlet tubes, the joints being kept away from the action of the hot gases.

Holt's superheater is of the U-tube design, and is said to have been fitted to boilers at Saltaire in 1866.

The Davey-Paxman superheater, as shown at the Glasgow Exhibition, was composed of seven elements, each consisting of one divided header, the compartments of which were connected by a series of single loop or U-shaped tubes extending horizontally into the combustion chamber. The headers were connected together by elbows in the rear, and the steam flowed seven times through the superheating chamber, commencing in the lowest rows of tubes, which are exposed to the greatest heat, and then rose to the topmost element and working downward to the second lowest and hottest element, from which it passed to the engine. It was independently fired, the hot gas from its furnace being under control so that it could be delivered under an adjacent boiler before passing to the economizer, or sent direct to the economizer and chimney, or passed into a main flue without rising through the superheater.

The Sugden superheater is another modification of the U-tube form. It is illustrated in The Engineer of January 23, 1903 (page 100). Other British superheaters include that of Prof. Watkinson, about which we may hope to learn some particulars from him; that of Chatwood, illustrated in Min. Proc. Inst. C. E., vol. cxxviii., pp. 110-111; those of Cruse, the Stirling Co., the Babcock Wilcox Co., and some others. Among those in use on the Continent are the Walther, the Steinmuller, the Reisert, the Meyer, the Buttner, the Durr, the Simonis & Lanz, the Göhrig, the Gohring, the Bohmer, and the Hildebrandt forms. Some of these are composed of straight tubes, some of zigzagged tubes, but a large number of some form of

* See also vol. xviii., p. 277.

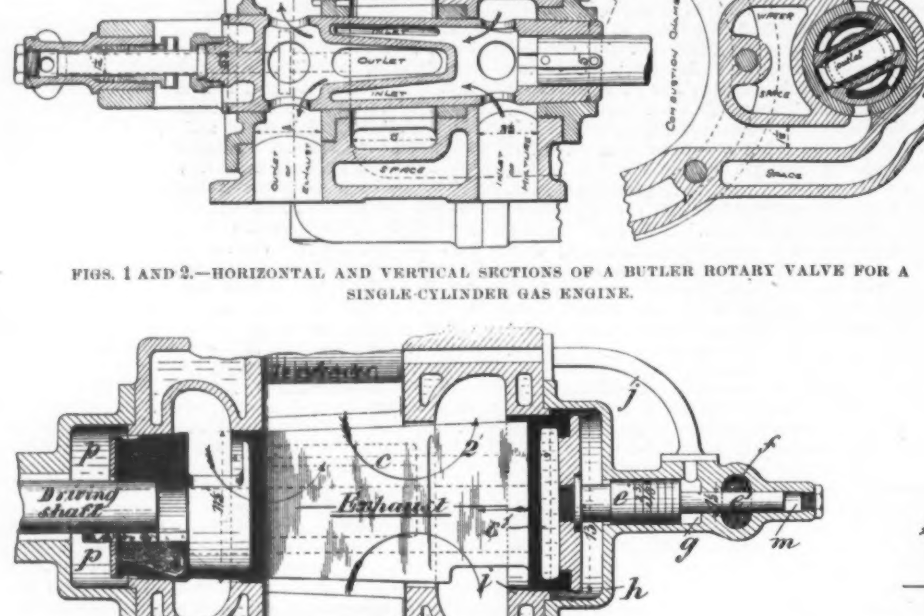
U tube. The last three named have various forms of coiled tube. All are illustrated in The Mechanical Engineer of June 8 and 22, and July 13, 20, and 27, 1901.

One form of superheater has been proposed by R. Wolf for locomotive type boilers. Another arrangement more suitable for locomotives proper has been proposed by Mr. J. Riekie. Space is not available for a description in detail of all these forms, but a few words must be devoted to the Schmidt arrangement before concluding this section.

In one form it consists of spirally-coiled tubes, and in the independently-fired variety the tubes are horizontally coiled. They are arranged so that the saturated steam from the boiler meets the hottest gases. In the spirally-coiled form the lowest coils, composed of eight tiers containing five coils each of spirally-wound 2-inch pipe, constitute the economizer, the eight tiers of 2¾-inch pipe directly above forming the superheater. The wet steam enters below and passes through the first four tiers, then to the eighth, and flows downward to the fifth, from which it is withdrawn. A somewhat similar arrangement is observed in the other form.

Mr. Rowan concluded his paper by referring at some length and in an interesting manner to the use of superheated steam.

GAS ENGINES FOR ELECTRIC LIGHTING, FITTED WITH A NOVEL ROTARY VALVE.



FIGS. 1 AND 2.—HORIZONTAL AND VERTICAL SECTIONS OF A BUTLER ROTARY VALVE FOR A SINGLE-CYLINDER GAS ENGINE.

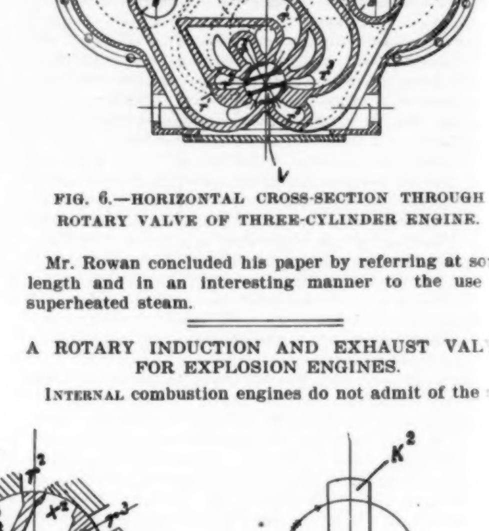
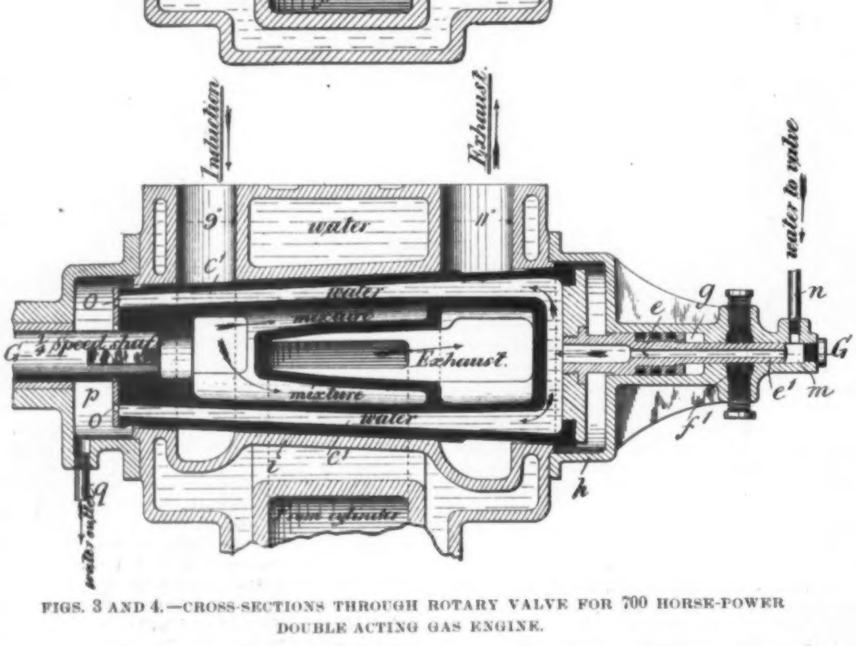


FIG. 6.—HORIZONTAL CROSS-SECTION THROUGH ROTARY VALVE OF THREE-CYLINDER ENGINE.



FIGS. 3 AND 4.—CROSS-SECTIONS THROUGH ROTARY VALVE FOR 700 HORSE-POWER DOUBLE ACTING GAS ENGINE.

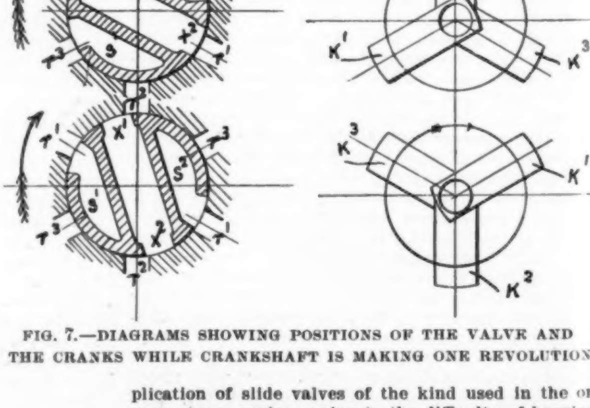


FIG. 7.—DIAGRAMS SHOWING POSITIONS OF THE VALVE AND THE CRANKS WHILE CRANKSHAFT IS MAKING ONE REVOLUTION.

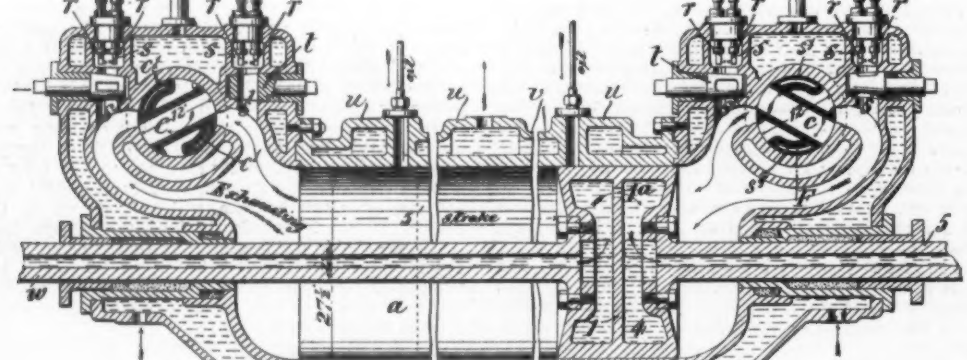


FIG. 5.—CROSS-SECTION THROUGH CYLINDER AND VALVES OF 700 HORSE-POWER DOUBLE-ACTING GAS ENGINE.

A ROTARY INDUCTION AND EXHAUST VALVE FOR EXPLOSION ENGINES.

INTERNAL combustion engines do not admit of the application of slide valves of the kind used in the ordinary steam engine, owing to the difficulty of keeping a slide valve gas tight on its seat against the pressure of explosive action in the cylinder, which is opposed only by the pressure of the atmosphere for keeping the valve against its seat. The explosion engine is in this respect entirely different from all engines actuated by compressed air, steam, or other fluids under pressure; and the gas and oil engines in which slide valves have been used have consequently required a cover at the back of the valve for holding it in place. In these cases the face of the cylinder, as well as the cover and both sides of the valve, have been of necessity very accurately faced.

The valves in most general use in all classes and sizes of explosion engines are of the lift or poppet order. These disk valves—whether with flat or conical seats—when used for the exhaust, always require a cam or other operating mechanism to open them against the pressure of the gases in the cylinder at about the termination of the power stroke. This pressure may be as high as 40 pounds per square inch, and, consequently, the cams, levers, and gearing used require to be of substantial proportion. It is also quite general practice now to provide cams or other operating mechanism for the induction valves used for the admission of the explosive mixture. Each cylinder thus requires two separate valves with lifting or opening mechanism.

The balanced rotary valve introduced by Mr. Edward Butler, of Gleneldon Road, Streatham, London, England, controls both the functions of induction and exhaust of the gases to and from the motor; and further, as may be seen in the illustrations, can be used for two or three cylinders, thus dispensing with two or three sets of valves and gearing as ordinarily used

These rotary valves are made with a 10 per cent taper and are held up gas tight to their seat by a small piston or plunger (*e*, Figs. 3 and 4) on the stem, which fits in a small cylinder of its own (*g*, Figs. 3 and 4) connected to the explosion chamber by a curved pipe, *j* (Fig. 3). The tendency for the valve to be forced out of its seat by the difference in sectional area of its two ends is by this means neutralized. The openings from the valve to the cylinder are also placed on opposite sides of the seat, the valve being thus practically held in a "floating fit" and perfectly balanced in both a lateral and endwise direction. Another advantage is the absolutely positive and accurate timing obtained in the opening and closing of both supply and exhaust, these operations being entirely unaffected by variations in speed of the engine. Its action is also quite silent and the frictional resistance very low, the speed being only one-fourth the speed of the engine crank whether used for one, two, or three cylinders.

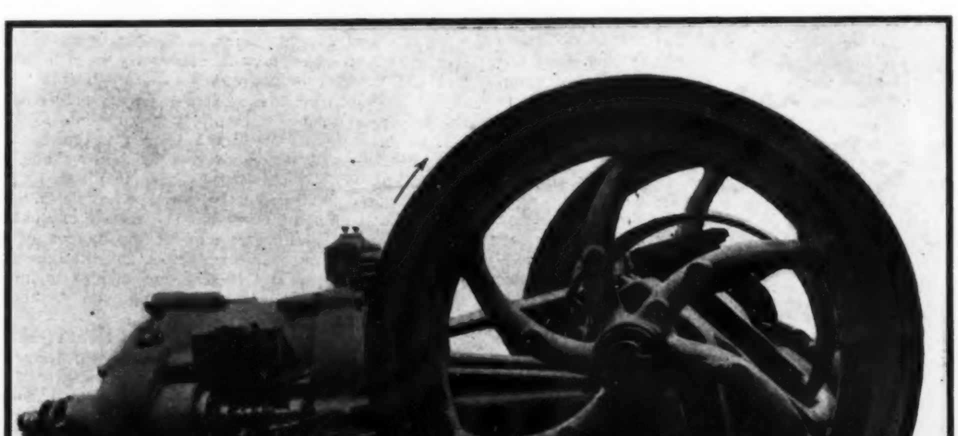
No power is lost in opposing the pressure in the cylinder, as in the case of lift valves. The form, application, and method of working a rotary valve for a stationary engine with one cylinder having a 13½-inch bore and a 22-inch stroke will be seen on reference to Figs. 1 and 2, the inlet and outlet passages being here marked, as well as the principal dimensions for an industrial oil or gas engine of this size, i. e., capable of maintaining a working load of 35 B. H. P. For all engines of this size and under, the valve does not require water cooling, it being simply a chambered plug of cast iron with two longitudinal partitions dividing the central exhaust passage leading to the larger end from the two D-shaped induction passages leading to the smaller end of the valve. Lateral port openings coincide with two oppositely placed openings in the valve seat, and communication is opened with the cylinder at each half revolution. A photograph of this engine is shown below. Another picture shows an automobile charette for three persons, fitted with a 4 B. H. P. motor in which a rotary valve of exactly this model is used; the inventor is here shown on the rear seat. For larger engines than the above, the valve is better cooled as shown in the sectional views, Figs. 3, 4, and 5, which represent a valve for a 700 I. H. P. double-acting engine with one valve placed at each end of the cylinder. The cooling water is fed into the hollow stem at the larger end and flows along passages immediately under the working surface, in this way preventing overheating in engines of the largest size. Engines having a 15-inch diameter cylinder are, however, in use with a rotary valve not water-cooled. The wear, which is very slight, is compensated for in an automatic manner by an end adjustment of the valve of about one-eighth of an inch in a year's constant use, in the case of the valve shown in Figs. 1 and 2, an allowance is made for ten years' wear in the end clearances of the valve at the smaller end.

In engines with two and three cylinders, the portways leading to the cylinders are arranged in pairs, as in the single-cylinder engines, and all communicate with the one valve. A reproduction from a photograph of a triple-cylinder combined gasoline and gas engine of 100 B. H. P., built on the compound principle, is shown at the right, this, as well as the single-cylinder engine shown, being used for electric lighting.

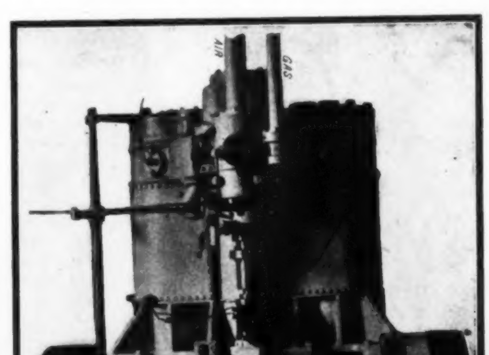
Fig. 6 is a plan sectional view of the combustion chamber casting of a three-cylinder vertical engine with one of these valves, the arrangement of the portways being indicated by the passages r^1, r^2, r^3, and the combustion chambers of the three cylinders by B^1, B^2, B^3. The positions of this valve for the four phases of a complete cycle of two revolutions are clearly indicated in Fig. 7, where the three cranks, K^1, K^2, K^3, are also shown in four positions with an advance in each case of half a revolution. The valve itself is exactly identical with the valves used for the single engines and rotates, as in them, once every four revolutions of the engine crank-shaft. The induction passages are shown by S^1, S^2, and the exhaust passage by X^1, X^2; the valve is held in its seat by a balancing piston, and is driven by a worm and wheel from a side shaft driven from the crank shaft by a silent chain.

THE INVENTOR ON AN AUTO CHARETTE HAVING A MOTOR FITTED WITH HIS ROTARY VALVE.

The rotary balanced valve would seem to have many advantages over the usual poppet valves, and especially so in an engine with three cylinders, which appears to be an ideal form for a high-speed engine in which silent running and simple action are the first consideration.



35-BRAKE-HORSE-POWER STATIONARY GAS ENGINE FITTED WITH A ROTARY VALVE.



100-BRAKE-HORSE-POWER, THREE-CYLINDER, GAS ENGINE USING A SINGLE ROTARY VALVE.

GAS ENGINES FOR ELECTRIC LIGHTING, FITTED WITH A NOVEL ROTARY VALVE.

A NEW METHOD FOR TESTING STEEL RAILS.

In a paper presented at the meeting, on January 5 last, of the Académie des Sciences, by Mr. Maurice Levy, Mr. Ch. Fremont gave a detailed description of a new method for testing rails which we take the liberty to repeat below. According to the contracts, all rails must be subjected to three varieties of tests before they may be accepted: a test by drawing out, in order to measure the resistance and ductility of the steel; a test for bending or flexion by means of a steady pressure, to ascertain whether the limit of elasticity is high enough; and finally the bending or breaking test by means of a violent shock, such as is effected by the fall of a hammer or weight, to prove whether the inherent resistance of the rail is sufficient.

In theory at least, this third trial is the most important, for if the metal is too soft, the rail will become more or less rapidly deformed, whereas if the inherent resistance is not sufficient, the rail is very apt to break while in use. Cases of such rupture have been known, not only when in use, but even in the handling of the rails during the transport to the place where they were to be laid, which proves that the rails accepted at the mill are sometimes brittle. However, there is often considerable difference between the results following an actual application of the above process, and those from real service; in the case of the hammer test, the rails are presupposed to be homogeneous, and they are expected to distort but slightly. Having determined upon a minimum arc of flexion, the active quantities, such as the weight of the hammer and the distance it must fall, are calculated, so that the shock shall not cause the rail to break.

Now it often happens that the rails are not of equal density throughout, and it is this absence of homogeneity which causes the disagreements between the test results and those of actual practice.

The heterogeneity of the rails arises from two causes which may even be coexistent.

1. The steel ingot may contain a pocket or depression (pipe) running through considerable of its length, which is not completely eliminated in the rolling of the rail; hence the central part or core of the rail is unsound and contaminated by segregation. Now a rail under these conditions may readily resist the hammer test, because its exterior surface being of good quality, alone receives the shock; but in the roadbed in service, under the continuous tremblings and vibrations caused by the trains, the unsound portion disintegrates, cracks, and the fissures finding their way into the healthy part of the rail, finally cause ruptures.

2. A second cause of the heterogeneity of the rail arises from the treatment it receives during the heating, rolling, and cooling processes; the core or center portion of the rail may be fragile, while the exterior surface may be moderately tough.

Accordingly, it is to be noted that in these two cases of dissimilitude, it is always the central portion of the rail which is likely to be defective, and that the hammer test has little chance of disclosing the hidden weakness, because that portion of the metal which is subjected to the test is the exterior, and generally of good quality.

It is reasonable then to bring the hammer test more especially to bear upon the central core of the rail crown, and this is just what I have accomplished in a series of tests which permit me to establish the exactness of the principle involved. My method of operating is to select a portion of a rail, say 0.50 meter long, and at its longitudinal center make an incision or slot

60 millimeters long, terminating in two semi-circles having a radius of 15 millimeters, said slot penetrating to the center of the crown which is to undergo the trial or extension by shock. Every piece so prepared is placed upon two supports 0.40 meter apart, consisting of two blocks of tempered steel of semi-cylindrical form and having a diameter of 14 millimeters. The slotted face being turned down, the rail receives the impact of the hammer falling from a height of 5 meters and possessing a weight sufficient to break the sample or a similar piece of the best quality of metal.

After the rupture, the pieces are again placed together, and the strength of the metal is given both by the elongation it has suffered, obtained by the careful remeasurement of the slot, which was of course previously calipered and noted, and the chord of the arc of flexion. With rails of standard quality I have, in this manner, obtained, in a piece of 0.50 meter long, chords of the arc of flexion measuring from 6 to 20 millimeters in length, while many of the other rails have not given any appreciable arcs or chords. By measuring, after the shock, the impressions made upon the rail by the supports and comparing them with the previously noted impressions caused by the static pressure test, we may arrive at the maximum effort exerted during the impact. In this test, then, we obtain the measure of effort or resistance to compression and the space passed through during the deflexion, and from these we may deduce the amount of work necessary to rupture the trial piece. Ordinarily, in practice, for the acceptance of rails, it is sufficient to fix upon a minimum of flexion. By operating on the pieces 0.50 meter long, taken from the rails during the process of manufacture, one is really making the test within 0.25 meter of the end of the rail in actual use. The insignificant length of the trial piece, taken as it is from the portion cut away in the finishing, admits of performing these tests much more frequently and economically than in the practice now in vogue.

THE INFLUENCE OF PASTEUR ON MEDICAL SCIENCE.*

By C. A. Herter, M.D., of New York.

To one who treasures memories of student days spent in your pathological laboratory, when each member of a small and favored group worked under the personal guidance of the great teacher whose unselfish labors have done so much for science in this country, it is indeed an exceptional privilege to address those who represent the School of Medicine that has grown since then to be the model for many an older institution. Yet I am conscious that this very privilege entails a risk proportioned to the largeness of the opportunity of using unworthily the precious moments which fortune has bestowed on me. My choice of subject has not, I fear, lessened this hazard, for I have chosen to speak to you of one of the most significant men of the past century, whether we consider him as a person, as an investigator or as a public benefactor. I pray you, therefore, deal gently with the shortcomings of an undertaking so difficult and ambitious as that of estimating the influence of a great career on the advance of medical science.

Louis Pasteur first saw the light of day on December 27, 1822, in an humble dwelling in the little town of Dôle in the Franche Comté. His parents had small means and limited social opportunities, but through the exercise of forceful character and unusual fidelity to elevated ideals of life, managed to give him a fair elementary education. The father, earnest, industrious and intellectually ambitious, instilled into his son the desire to become a useful and respected member of society, shielded him by constant companionship from the vulgar temptations of youth and fired him with a love of country which a long and honorable career as a soldier of Napoleon had strongly fortified. The mother of young Pasteur was prevented by household cares from sharing closely the intellectual interests of her only son, but showed the depth of her affection by making many a little sacrifice to further his education. She was a spirited woman, possessed of lively imagination and quick intelligence, and it is reasonably clear that the unusual artistic perceptions of Pasteur mark the perpetuation of these maternal gifts. Although the school days of Pasteur appear to have given little indication of an exceptional future, the lad showed some qualities which distinguished his work in later life. In his daily tasks, at which he worked faithfully and deliberately, he showed the most scrupulous accuracy and truthfulness, attributes which are the more noteworthy for the reason that they belong to a temperament enriched with a strong vein of romanticism, which for a time found expression in a fervid devotion to poetic literature. Moreover, Pasteur showed, while still in his teens, a pronounced capacity for portraiture. During his three years of instruction at the Collège Royal of Besançon, which he entered at eighteen years of age, the young student was more absorbed in literature and art than in science, and impressed his colleagues as being surely destined for an artistic career. The courtesy of Mr. Philip B. Marcou, of Cambridge, has made it possible for me to examine closely two fine examples of Pasteur's work at the end of this Besançon period. Although these portraits disclose the manual hesitancy of the imperfectly trained craftsman, they bear an unmistakable air of distinction and are executed with a respect for detail which is highly remarkable. Anyone who sees these youthful works is likely to feel that eyes so sensitive to these minutest particulars of form, would be apt to see many things which others had failed to notice, and it is noteworthy that Emil Fischer, whose calm judgment is well known, has expressed his belief that Pasteur's crystallographic discoveries were facilitated by his artistic perceptions.

The years at Besançon were followed by a highly important course of study at the Ecole Normal of Paris, during which Pasteur formed the determination to devote himself to science. For the first time in his life, the gifted impressionable young man found himself under the influence of a creative scientific mind of the highest order, a mind which has left a large and permanent mark upon the history of chemistry and which could not fail powerfully to mold the plastic intelligence of Louis Pasteur. Jean Baptiste Dumas, who had already discovered the great principle of substitution, united to his genius as an investigator the charm of a finished and spirited delivery. His Sorbonne lectures fairly captivated the young student and gave definite and lasting direction to his study and fancy and, later, to his researches. Other teachers of a superior order contributed to lead Pasteur into the promising and fascinating paths of physics and chemistry. The attractive Balard, to whom bromine had first surrendered the secret of its existence, reinforced the chemical teachings of Dumas, and the admirable lectures of Delafosse aroused an enduring interest in the subtle beauty of crystalline forms. But it is to the strong intellect of Dumas that Pasteur owed his first grasp of the great principles of science and that enthusiasm for work, which made it possible to ignore the harsh and depressing material conditions that prevailed at the Ecole Normal. The recognition by young Pasteur of the importance of correlation in the physical sciences is an impressive feature of his mind at this period of close association with great chemical investigators. Evidence of this recognition exists in a singularly fine letter, full of enthusiasm for science, which he wrote to his colleague, Jules Marcou, then entering on his distinguished career as a geologist.* "Before finishing your letter," says young Pasteur, "I had already regretted that your studies in chemistry were incapable of responding to what geology will often ask of them. . . . I know very well that many distinguished geologists have no broad conception of chemistry, but I believe this to be a great pity and I think that geology has not often enough turned to chemistry." The chemist of twenty-three summers held a point of view which was destined very soon to aid him in a memorable research.

It was in the field of crystallography that Pasteur, led by an interest in the ingenious and delicate methods of the science, first showed his exceptional capacity to observe minutely things and processes and to correlate and interpret the results of his observations. He began by carefully repeating a series of crystal measurements of tartaric acid, racemic acid, and their salts, shortly before published by Provostaye. During the study of the recrystallized salts of tartaric acid he observed one very important but unobtrusive thing which the distinguished physicist had overlooked—regular evidences of hemihedral facets. All the tartrates showed a weak kind of isomorphism which is apparently forced on them by the tartaric acid group, whatever other element may exist in the compound. Guided, as he tells us, first by the observation of Biot that tartaric acid and its compound rotate the plane of polarization, secondly by a relationship between the crystalline form of quartz and the direction of rotation, and finally by Delafosse's conception that hemihedrism depends on definite crystallographic laws, Pasteur concluded that there is a relation between the hemihedrism of the tartrates and their optical activity. An unexpected discovery soon proved this to be true in a conclusive and beautiful manner. One day in the dark library of the Ecole Normal, Pasteur's eyes lighted on a remarkable paragraph from the writings of the Berlin chemist and crystallographer, Mitscherlich, relative to two different saline combinations of tartaric acid, the tartrate and the paratartrate (or racemate) of sodium and ammonium. This note stated that these two types of double salts have the same chemical composition, the same crystal form with equal angles, the same specific gravity, the same double refraction, and that in consequence of this their optical axes form the same angles. Their water solutions have the same refraction. The dissolved tartaric acid salt rotates the plane of polarization and the racemic salt is indifferent, as had been found by Biot for the whole series of salts. "But,'" continues Mitscherlich, "the nature and the number of atoms, their arrangement and their distance from one another are the same in both bodies." The contradiction expressed here upset all Pasteur's physico-chemical ideas and persisted for months in his mind like an interrogation point. But the day came when experience cleared up the mystery by demonstrating that there is really a difference between the tartrates and the racemates which Mitscherlich had not noticed. The former bore hemihedral facets on the right side and always rotated the plane of polarization to the right; the latter bore facets both on the right and on the left sides and did not rotate polarized light at all. Moreover, it later appeared that this inactive racemic acid may be caused to crystallize in such a way that the crystal mass consists of equally numerous dextrorotary and levorotary crystals, the former possessing hemihedral facets on the right side, the latter hemihedral facets on the left side. Both kinds of crystals were isomorphous, but the isomorphism was that of two asymmetric crystals, of an object to its reflected image. The weighty and surprising discovery had been made that indifferent racemic acid crystallizes into equal quantities of ordinary dextrorotary tartaric acid and the newly observed levorotary tartaric acid.

This research on the tartrates, culminating in 1848 with the discovery of the nature of paratartaric or racemic acid, proved that Pasteur had already made himself master of the experimental method.

Three distinct practical results followed in the train of this research as a consequence of continued studies of the crystallographic problem. In the first place there came to light numerous fresh evidences of a relation between molecular constitution, crystalline form, and the property of rotating the plane of polarization. It is true that Pasteur seriously entertained some ideas of a highly speculative nature regarding the operation of dissymmetry in nature, ideas which involved him in fruitless experiments; but on the other hand the tangible and positive results of his work must be recognized as forming the basis of the modern doctrine of the asymmetrical carbon atom which has so illuminated our ideas of the spatial arrangements of the atoms within the molecules of organic substance. Secondly, the research on the tartrates led Pasteur to the recognition of a series of optically inactive compounds, including inactive malic acid and inactive amyl alcohol. Finally, the crystallographic researches were the bridge over which the far-seeing investigator passed on the way to lay the foundations of a new biological science, a science which has effected a veritable revolution in our conceptions of medical problems. Cagniard-Latour, Schwann, and Kützing, by knowledge gained in their experiments on alcoholic fermentation, held one pass to the great secret, but saw not the fields of discovery to which it might have led them. Pasteur made his way thither by a singularly trustworthy intuition. Greatly impressed with the circumstance that optically active substances like the sugars, the tartrates, the malates, the citrates, the gums, and the proteids seemed to be confined to the organic world and were not to be found outside the tissues of plants and animals, Pasteur made a simple yet decisive experiment. To some pure crystallized inactive ammonium paratartrate he added fermenting albuminous material. After a time the fluid was examined with the polariscope. It rotated strongly to the left. This levorotation was obviously due to the fact that the dextrorotary constituent of the paratartrate had been decomposed. An optically inactive fluid had been converted into an optically active fluid. According to Pasteur's theoretical views this striking change indicated the mediation of living matter. The activity of unorganized purely chemical ferments could not, in his judgment, explain the facts; micro-organic life must be in some way concerned. Fortunately the mind in which this conception was born was also capable of testing its correctness by the most rigid methods of investigation. Fortunately, too, the external conditions favored a studious excursion into the processes of fermentation, for Pasteur was called in 1854 to a professorship at Lille in a region of distilleries which involved the training of young men to proficiency in industrial chemistry and made it essential to get new light upon the various kinds of fermentation.

At this period of Pasteur's career the prevalent doctrines of fermentation were singularly unsatisfactory and uncontrolled by searching experimentation. The versatile Spallanzani had nearly a century before taken the important step of showing that putrescible liquids can be permanently protected from the processes of fermentation and decomposition by boiling and exclusion of air. Then Gay-Lussac, inspired by the revolutionary but constructive work of Lavoisier, made his clever attempt to show that the results of Spallanzani were due to the exclusion of the oxygen of the air from the decomposable materials, and the ingenious French cook Appert put this erroneous idea to important practical use in his widely employed method of canning perishable foods.

Thus in the early days of the nineteenth century people were content to think of alcoholic fermentation as purely a chemical process. The first great blow to this widely accepted doctrine came from Theodore Schwann's incisive studies of the yeast plant in its relation to alcoholic fermentation. Very clearly did Schwann show that oxygen does not suffice to initiate the fermentation of sugar and that the necessary condition is the presence of something which is destroyed by heat—a living organism. Unfortunately he failed to maintain aggressively the new doctrine of the dependence of fermentation on micro-organic life. The result was that the new vitalistic hypothesis failed to make any important advance in the face of the sharp criticism and ridicule of so active and influential a teacher as Justus Liebig, whose word was nearly everywhere received as final in matters chemical and physiological.

To Liebig and to many others it seemed a retrograde step to assume that a living organism like the yeast plant is the cause of alcoholic fermentation, for the most advanced scientific thinkers were eagerly striving to explain the phenomena of life by physical and chemical laws and the rôle of "vital force" was being successfully restricted almost from day to day. Liebig pointed effectively to the fact that sugar undergoes other kinds of fermentation than alcoholic, such as lactic and butyric, but that nothing like a yeast organism was to be seen in these allied types of decomposition. It seemed to him that these various kinds of decomposition had one feature in common, the presence of a small quantity of nitrogenous substance.

* Address delivered at the opening of the Johns Hopkins Medical School, 1903.

* Mr. Philip B. Marcou has permitted me to read a large number of unpublished letters written by Pasteur to his father. The letter above quoted is dated June 10, 1845, and is one of a very small number belonging to this period.

This dead material operated as the real ferment, by communicating a kind of shock to the molecules of sugar or beef extract with which it came in contact, which resulted in the fragmentation of the molecule into smaller molecules, the essence of fermentation and putrefaction.

To Pasteur the position of Liebig was wholly unintelligible because it rested on prejudice much more than on experimental evidence. He resolved to investigate the subject of fermentations from the standpoint which he had reached by observing the fermentation of the paratartrates—that is to say with the preconceived idea that fermentation depends on the mediation of living organisms. The first notable paper in the long series which solved one of the most pressing questions in biology deals with lactic acid fermentation.* It might perhaps have been anticipated that Pasteur's first important utterance on the nature of fermentation would deal with the alcoholic form which has so great a commercial importance. He discovered, however, in lactic fermentation an admirable field on which to contest the ideas of Liebig and his followers, who were constantly pointing out that in lactic fermentation, so like the alcoholic form, there is nothing at all like a yeast ferment. This research ended, as is well known, in the discovery of a specific lactic acid organism or ferment, and in the cultivation of this and other organisms in an artificial medium free from albuminoids. Pasteur was not slow in forming the hypothesis that different types of fermentation are dependent on different types of micro-organisms, and this idea of specificity, soon established in relation to the ordinary decompositions, ultimately became the basis of our modern knowledge of the infectious diseases.

The research on lactic acid fermentation thus gave the *coup de grâce* to the chemical theory of fermentation at the same time that it marked the birth of the promising science of bacteriology. The development of a method designed to secure pure cultures from fluid media, the use of culture media of known composition, and the careful chemical study of products of decomposition, all belong to this early period of Pasteur's life and were achievements of the deepest significance for the future of the great department of knowledge which has revivified the biological sciences.

Another research on fermentation deserves more than passing notice on account of the extraordinary discovery which appears as its almost accidental by-product. This is the investigation on butyric acid ferments (1861). This research brought to light the fact that there are motile organisms capable of inducing a decomposition of sugar with the production of butyric acid. In the course of this research Pasteur saw that these organisms (whose motility was most puzzling on account of its suggesting animal life) behaved very differently according to their position with reference to the cover glass, those at the center being active, while those at the periphery and exposed to the air were checked in their movements.† From this casual observation came the fundamental conception of anaerobic life. All physiologists recognize to-day "a class of beings possessing such vigorous respiratory power," as Pasteur aptly says, "that they are able to live without the influence of the air by taking oxygen from certain compounds, thus occasioning in the latter a slow and progressive decomposition."

That Pasteur's original and searching examination of the problem of fermentation would one day lead him into a controversy over the unsettled question of spontaneous generation might almost have been predicted. The long discussion with Pouchet and Bastian, containing something of bitterness and not a little of the ridiculous, is a dramatic and animated chapter in the life of a peaceable but truth-loving man. As students of the influence of Pasteur on medical science, we need not pause to review this controversy, for its fruits are to be found in all his subsequent work on the specific nature of the infectious diseases. Yet this discussion, prolonged over nearly twenty years, and replete with instruction and entertainment, is worthy of a permanent place in the memories of scientific men.

After a public victory over Pouchet in 1862, which brought in its train the honor of election to the Academy of Sciences, Pasteur turned his attention toward two subjects of much practical interest, which seemed closely connected with the phenomena of fermentation. One of these was the manufacture of vinegar, the other the diseases of wine. The study of vinegar led to the recognition of the micro-organic nature of the vinegar film, or mycoderma, and brought acetic fermentation into line with lactic and butyric fermentations. It led also to the discovery that the oxidation of alcohol through the agency of the vinegar organisms may be carried too far, acetic acid being lost by oxidation to water and carbon dioxide. Then again Pasteur was able to aid the makers of vinegar by teaching them that the indispensable film formation can be facilitated by the actual transfer of the living ferment to the surface of the vinegar. In the study of the diseases of wine Pasteur achieved even more helpful practical results, for, after recognizing the dependence of sour, bitter, and muddy wines on the presence of definite types of living ferments, he was able to suggest a simple and efficient way of controlling these disturbing agencies by the use of moderate heat. From this recommendation has sprung the use of the widely employed method of sterilizing which we call Pasteurization.

In Pasteur's growing interest in these works of practical utility we can detect a tendency which was destined to bear rich fruitage in medical science—the inclination to employ the gifts of which he could no longer fail to be conscious in a manner likely to be directly helpful in relieving the needs of his fellow men. It was this attitude which made it possible in 1865 to lead Pasteur not without regret away from his studies of fermentation, to a wholly new sphere of endeavor. In that year the mortality among the silkworms of northern France was so great that the silkworm industry was threatened with total extinction and grievous famine was making its appearance in a land where comfort and contentment had long reigned. Dumas, acting for a senate committee, selected Pasteur to solve the mystery of the plague. To Pasteur's remonstrance that he knew nothing of the subject and had never seen a silkworm, Dumas answered, "So much the better, you will not have any ideas except those that come to you through your own observations." There were many unfriendly comments on this appointment, for some scientific men could not understand why a chemist should be chosen to cope with an obscure zoological problem. But Dumas knew his man and confidently relied on the great gifts he saw in him. It was quickly evident that his faith was not misplaced. Only twenty days after his arrival at Alais, Pasteur prepared a note in which he outlined a method of breeding from the eggs of silkworms free from disease. Unlike his predecessors, he made the moth the center of the efforts to regenerate the race of silkworms. "If the butterfly is sick reject all its eggs." It required five years of Pasteur's most devoted attention, five years beset with uncertainties and disappointments, to establish this almost clairvoyant conception on an incontestable scientific base. At the end of this period Pasteur and his highly skilled assistants had shown that there were two distinct diseases from which the silkworms died, pébrine or corpuscle disease, and flâcherie, a bacterial affection of intestinal origin. The former was proved to be a specific disease due to the psorosperm *Nosema bombycis;* the latter was believed by Pasteur to depend on a specific bacterium, but can probably be excited by several distinct varieties of bacteria. The pébrine disease, which was the chief scourge of the industry, was eradicated through the use of a careful system of breeding from eggs shown by microscopical examination to be free from infection. The immense practical importance of this method sociologically as well as financially, can be better left to the fancy than expressed in dollars and cents. But these immediate practical results do not adequately express the far-reaching effects of the great silkworm research which marks the entry of Pasteur into the realm of animal pathology, and is thus the vestibule of modern medicine. For it is true that the laws governing the propagation and development of the flâcherie disease have the most striking analogies to those of the diseases of man. The varying susceptibilities of different individuals to the same micro-organisms, the influence of the path of infection and the fact that flâcherie organisms acquire increased virulence after passage through the bodies of living silkworms, foreshadow discoveries in human pathology. The two volumes dealing with the diseases of silkworms, and dated 1870, are works whose contents should be familiar to every independent student of the infectious diseases.

The researches on the silkworm diseases had one practical effect of considerable importance for Pasteur's later career. The success with which Pasteur had solved his intricate and widely known problem made it natural that French investigators of animal pathology should in future turn to him as the man most likely to help them in their work, and this brought to him new opportunities for fresh successes.

It is likely that excessive work and mental stress in some degree contributed to the onset of the series of paralytic seizures which in October, 1868, threatened the life of Louis Pasteur. During the critical period of his illness many of the most distinguished scientific men of France vied with each other to share with Mme. Pasteur the privilege of nursing the man they loved so well, and of rescuing the life that had already placed science and a nation under enduring obligation, through discoveries which were either of the greatest practical utility or appeared susceptible of almost unlimited development. Had Pasteur died in 1868, he would have left a name immortal in the annals of science. Others would in some degree have developed his ideas. Already inspired by the researches of fermentation, Lister would have continued to develop those life-saving surgical methods which will forever be associated with his name. But we may well question whether investigations in biology and medicine would not have been, for a time at least, conducted along less fruitful paths. Who shall say how soon the great principle of experimental immunity to pathogenic bacteria, the central jewel in the diadem of Pasteur's achievements, would have been brought to light?

When Pasteur recovered sufficiently to resume work, it was soon clear to apprehensive friends that he had no intention of leaving his ideas to be worked out by other men. The miseries of the Franco-Prussian war deeply affected him, and could not fail to inhibit his productiveness, but after a time the unquenchable love for experimental research was once more ascendant, and there began a new epoch, the epoch of great discoveries relating to the origin and cure or prevention of the infectious diseases of man and the domestic animal. As in the case of Ignatius Loyola, it seems as if the lamp of genius shone with a larger and more luminous flame after the onset of bodily infirmity, in defiance of the physical mechanism which is too often permitted to master the will.

The hostility of Pasteur to Germany and all things Teutonic was greatly intensified by the events of the Franco-Prussian war and has left a somewhat regrettable impression on his scientific work. Desiring to contribute to the rehabilitation of his unhappy country, he was led to improve the processes of brewing with a view to increasing the wealth of France and at the same time lessening the yearly tribute to the despised people beyond the Rhine. It was easily shown that some of the diseases of beer are due to the action of bacteria allowed to take part in the process of fermentation. But it soon became clear that the mere exclusion of these micro-organisms does not insure a brew of good beer. The problem was considerably complicated by the difficulty of deciding what constitutes excellence in beer, and this situation was not helped by the fact that Pasteur, who disliked the German drink almost as much as he disliked Germans, could not distinguish one brew from another. Nevertheless, after many discouragements, he succeeded in establishing methods which much improved the character of French beers, methods involving the aeration of beerwort by sterilized air and the abandonment of open coolers. The results were far from satisfactory owing to the circumstance that Pasteur quite overlooked the part played by the undesirable forms of yeast—so-called wild yeasts—in the production of abnormal fermentations. In fact it is doubtful if he could have separated the different types of yeast by the methods at his command, for even in so late a work as the famous "Etudes sur la Bière," bearing the date 1876, we are struck with the inadequate character of Pasteur's devices for obtaining pure cultures of micro-organisms.

This work, with its tender dedication to the memory of Pasteur's father, was a highly important contribution to bacteriology in spite of its many botanical defects. It is really a bacteriological potpourri bringing together the writer's views on many questions, rather than a strict treatise on the diseases of beer. Besides chapters on the causes of bad beer, and our improved methods of brewing, the volume treats of the origin of ferments and furnishes conclusive experimental evidence against that plastic doctrine of the transformation of species around which the friends of the spontaneous generation fallacy were hopefully rallying. But by far the most striking and original chapter in this notable volume is that in which Pasteur formulated his physiological theory of fermentation—the startling theory that the essential characteristic of fermentation is life without air, life without free oxygen. This theory, if not entirely upheld by other biologists, has at least proved a powerful stimulus to new studies of this unexplored aspect of life.

Pasteur's life was prolonged a quarter of a century after the close of the war with Germany, and during a large part of this long period his mind dwelt almost unceasingly on two phases of the great biological and practical problem which it was his fortune to develop so fruitfully. One of these was the investigation of the etiology of disease as related to the activity of micro-organisms. The other was the experimental study of the amazing phenomena of immunity to the action of specific viruses or virulent micro-organisms. These two interdependent phases of bacteriological research culminated in one of the most remarkable discoveries of all time, remarkable for its practical results but even more striking as an example of the use of the imagination in science. It is well worth while to consider the chief events that ultimately led to the discovery of a method of immunization against the virus of hydrophobia.

The idea that some diseases are due to living micro-organisms was suggested by Boyle two hundred years before the days of bacteriology. From time to time thoughtful men took up this idea as worthy of discussion, but it received no substantial confirmation until Schoenlein, with the aid of the microscope, made his admirable discovery of the infectious nature of ringworm. This was in 1839. Within a few years Henle, the gifted anatomist of Göttingen, proposed an ingenious explanation of the infectious diseases which assumed the agency of micro-organisms, but the theory, though based on thoughtful clinical considerations, was deficient in experimental data and had little practical influence on medicine. It is scarcely surprising that the leading scientific minds of the epoch should have been hostile to any mere hypothesis of contagion by germs, for in their struggle against the ancient conception of a vital force, they regarded the idea of a *contagium vivum* exactly as Liebig had regarded Schwann's and Pasteur's doctrine of fermentation. Even the illuminating cell doctrine of Virchow was not especially favorable to the idea that living organisms from outside can excite disease by fixing themselves and developing in the body. Pasteur's training and temperament and genius admirably fitted him not merely to detect the great central truth of etiology, but to force it, in spite of stubborn opposition, upon a doubt-

* During the years 1858 and 1859 Pasteur did highly important work on alcoholic fermentation. His views as to the significance of molecular dissymmetry had already led him to regard the levorotary action of amyl alcohol as an indication that this regular product of alcoholic fermentation is found by the mediation of living organisms. It was in fact his study of amyl alcohol (1855), together with the experiment on inactive ammonium paratartrate, that incited Pasteur to make researches on the method of fermentative processes. His superior chemical training under Dumas was used to great advantage in all the researches on fermentation. In the case of alcoholic fermentation Pasteur showed that the acid formed is neither acetic nor lactic acid, but that succinic acid and glycerine are regular and not unimportant products. Lavoisier and Gay-Lussac represented the sugar in alcoholic fermentations as splitting wholly into alcohol and carbon dioxide, but the work of Pasteur showed that five or six per cent of all the sugar is not decomposed in this way.

† Pasteur fell into the error of describing the butyric acid organisms as infusorians and thought he had shown that animal life can exist without oxygen.

ing world half stunned at the boldness of the new doctrine. But while he took by far the larger part in compelling this revolution in the conception of disease, the way was prepared by others, and especially by the fine observations of the biologist Casimir Joseph Davaine and the accurate and ingenious experimental methods of Robert Koch.

Davaine, while assisting the clinician Rayer in the study of the devastating anthrax plague in 1850, observed little thread-like bodies in the blood of animals dead of this disease. Ten years later Delafond observed these little threads to be living organisms with the power of multiplying outside the body. Thirteen years after his first observations Davaine, incited by Pasteur's suggestive work on the butyric acid ferment, reopened his study of anthrax and confidently proclaimed that the organisms he had found were the cause and the only cause of anthrax. But it required the superior technic of Koch unquestionably to obtain the anthrax organisms in pure culture, to follow the cycle of their development in the animal body, and thus to place the important discovery of Davaine on an impregnable scientific foundation. Pasteur, entering this field a little later, independently worked out some of the most striking features of the etiology of anthrax and convinced the best scientific minds of France of the relationship between the bacilli of Davaine and the perpetuation of the anthrax plague.

(To be continued.)

PRELIMINARY REPORT ON AN ARCHEOLOGICAL TRIP TO THE WEST INDIES.*

By WALTER FEWKES.

INTRODUCTION.

THE archeological results of a brief visit to Porto Rico in the spring of 1902 were so promising that the author was encouraged to renew his explorations in the following winter, when he could devote more time to his researches. Therefore in November he returned to the island where he continued until the close of May, 1903, with the exception of a month spent in Santo Domingo. The size of the collection of prehistoric objects made on this visit so far exceeded expectations that a mere preliminary report can call attention only to the more important results. These will be considered under two general heads—Excavations, and Description of Specimens. Excavations were confined to Porto Rico and were made in caves, village sites, and dance inclosures. The objects considered under "description of specimens" embrace those which were purchased and brought back to Washington, as well as others that could not be obtained.

EXCAVATIONS.

The nearest approach to ruins of prehistoric Porto Rican structures, now surviving, are inclosures surrounded by aligned stones, set on edge, which occur in the less frequented parts of the island. These inclosures are square or rectangular and their floor level is slightly below the surrounding surface. The stones forming their boundary walls are roughly hewn and sometimes bear pictographs, in one or two cases the upper end being rudely fashioned to represent the head or body of an idol. These structures, which are undoubtedly prehistoric, are sometimes called *cercados de los Indios*, or "Indian inclosures." They are also locally known as *juegos de bola*, from the belief that they were used in a game of ball, called *batey*, of which the Indians were fond. Oviedo describes this ball game, saying that it was played in inclosures outside the pueblos, where there were seats for the cacique and the spectators. Following analogy, we may suppose that other gatherings took place in these inclosures, since they were situated near the villages. We know, for instance, that the islanders had elaborate mortuary dances, called *areitos*, which occurred at the burial of a chief or cacique, and from knowledge of kindred people it is probable that these *areitos* were performed near the graves of the dead. Historians are silent regarding the position of the Antillean cemeteries or the situation of the plazas in which the *areitos* were performed, but a suspicion that the latter occurred in the *juegos de bola*, the only known prehistoric structures remaining in Porto Rico, suggested to the author that cemeteries should be sought in their vicinity. With this thought in mind he chose for investigation a *juego de bola* near Utuado, where there are many of these structures in a fairly good state of preservation.

The inclosure chosen for excavation lies about three miles from Utuado, on the left side of the road to Adjuntas. Several mounds are situated on the south side of this inclosure, one of which is partly cut through by the neighboring road. A few feet below the surface, in this exposure, the author found fragments of prehistoric pottery and a few human bones, a discovery which led him to dig a trench completely through the mound. In the course of this work, which occupied several workmen the greater part of a week, ten skeletons were exhumed within a limited area, and several skulls, two of which were comparatively well preserved, were found. While the majority of these human remains were so decayed that they crumbled before they could be taken from the moist soil, it was evident that they represented Indian interments. The skulls showed the artificial flattening characteristic of the Antilleans, and the position of the larger bones indicated that some of the bodies had been buried in a sitting posture. Prehistoric implements and a mortuary food bowl were found near one of the skeletons. These and other evidences led to the conviction that the mound excavated was an Indian cemetery, the first of its kind ever found in Porto Rico.

The position of this cemetery has an important bearing on the interpretation of the neighboring inclosure, for if the *areitos*, or mortuary dances, were held at the burial mounds, they must have taken place in the *juegos de bola* near the cemetery. Consequently these inclosures were not only places for the game of *batey*, as popular legends assert, but also for the performance of mortuary dances, during which songs were sung extolling the illustrious deeds of the dead in peace and war and their magic power in aid of the living.

1
2
3


FIG. 1.—CELTS WITH STONE HANDLES FROM SANTO DOMINGO.

1. Length, 9¼ inches. 2. Length, 7¾ inches. 3. Length, 9 inches.

1
3


FIG. 2.—STONE IMPLEMENTS FROM SANTO DOMINGO AND PORTO RICO.

1. Polishing implement (length, 8¼ inches). 2. Polishing implement (length, 4¼ inches.) 3. Ceremonial celt (length, 9¼ inches). 4. Ceremonial baton (length, 14 inches).

CAVE EXPLORATION.

Porto Rico has many noticeable caves, some of which were utilized by the aborigines of the island. While there is no good evidence that these caverns were dwellings of the Indians for any considerable time, there is abundant proof that they were resorted to in prehistoric times for several purposes. They undoubtedly served, especially after the advent of the Europeans, as places of refuge and perhaps for temporary shelter or for the performance of secret rites when the aboriginal cultus was prohibited in public. There are many evidences that the caves were used for burial, which implies that they were places of ceremony, especially as ancestor worship was the main element in the Antillean religion. The walls of many of these caverns bear religious symbols, and niches where idols of stone or wood once stood can still be seen. These caverns are reputed to have yielded many prehistoric objects, and it is probable that others could yet be found in their floors. The author was anxious to test this belief by systematic excavation, so after visiting many of the most notable caves he finally chose for extended study one, most conveniently situated for that purpose, on the coast, three miles north

* From Smithsonian Miscellaneous Publications.

of Manati, called Cueva de las Golondrinas, "Cave of the Swallows."

Excavations in this cave showed that it was once frequented by the aborigines, while pictographs on the walls gave other evidence of their former presence. There were found among the debris, on the floor, many fragments of the pottery peculiar to the islanders, and other evidences of primitive life, among which were broken celts, bones of animals which had served for food, and also ashes and charcoal. All of the implements and utensils were of ancient manufacture and so numerous that many people must have frequented this coast region and used this cave as their camping place. A few broken human bones were also uncovered, but whether they indicated former anthropophagous feasts or hurried interments could not be determined. The trenches dug in the cave floor through ten feet of debris showed, at all levels, art objects similar to those occurring on the surface, indicating no change in culture. There was no evidence of any great modification between the life of the earlier and the later occupants, and no satisfactory proof that the occupancy of the cave was of very great antiquity.

DESCRIPTION OF SPECIMENS.

In the following pages the author will comment in a general way on the unique as well as on some of the more striking and unusual specimens which he saw or obtained on the trip. It will not be possible at this time to compare these with similar objects already known; a detailed description is reserved for a more extended report, when available documentary and historical references to the uses of many of the objects will be freely quoted. Only such specimens are here considered as will indicate the wealth of new material possible to obtain in this almost neglected field. The size and value of the collection acquired during a comparatively brief sojourn is the best possible evidence of the promise which the West Indian field affords to the archeologist.

The collection brought back to Washington, including the specimens obtained by excavation and by purchase, numbers over twelve hundred specimens. These objects vary in scientific value, for while many are duplicates of forms already known to students, others are entirely unique. The most important collection obtained by purchase was from the Right Reverend Fernandez Meriño, formerly president, now archbishop of Santo Domingo. This famous collection, which was the best on the island, contains about one hundred and ten specimens, most of which are unique. Considering our lack of knowledge of the antiquities of Santo Domingo, and the scarcity of specimens from this island in the National Museum, the acquisition of this rare collection, gathered with care during many years by a learned man, is gratifying.

Collections were also purchased in Porto Rico. Among these may be mentioned that of Señor Zeno Gandia, formerly owned by the Gabinete de Lectura, a scientific and literary society which formerly existed in Ponce. A small collection was also acquired from Señor Angelis of Catania, and another from Señor Fernandez of Loquillo, in the eastern end of the island.

But by far the largest number of specimens from Porto Rico was obtained, one or two at a time, from the natives, commonly called *Jibaros*. For this purpose the author went from house to house in the poorer sections of several towns, as Manati, Ciales, Toa Alta, Toa Baja, Vega Alta, and Dorado, soliciting these objects directly from the people. Almost every small cabin was found to possess one or more perfect celts, called *piedras de rayo*, or thunder-stones, concerning which the owners possessed considerable folklore.

But the material obtained by purchase forms only a part of that made use of by the author in his studies. He availed himself of the opportunities afforded by his trip to study local collections which could not be acquired. Among these may be mentioned a Dominican collection owned by Señor Imbert, of Puerto Plata, who, although unwilling to sell, gave every facility for study, kindly allowing the author free use of his notes and catalogue, in which are recorded the localities from which the specimens were obtained. The Imbert collection contains several unique objects, among which are a wooden idol (the best yet discovered in the West Indies), five sticks once used to induce vomiting, several pieces of prehistoric pottery of unusual shape, and numerous stone implements and rare fetishes. Another Dominican collection, owned by Señor Desangles (a native painter whose picture of Conoabo attracted attention at the Pan American Exposition in Buffalo), contains among other prehistoric objects, a human effigy made of burnt clay and probably unique. Señor José Gabriel Garcia, an author and a member of the leading publishing firm in Santo Domingo city, has many Indian specimens. The late Dr. Alesandro Llenas, of Santiago de los Caballeros, owned a well-preserved aboriginal wooden stool and two prehistoric Antillean skulls; and a Mr. Hall, an American of Puerto Plata, has a collection of stone objects. Both of

FIG. 4.—ORNAMENTAL STONE PESTLES FROM SANTO DOMINGO.

1. Height, 5⅛ inches. 2. Height, 9 inches. 3. Height, 4⅛ inches. 4. Height, 4¾ inches. 5. Height, 5¾ inches. 6. Height, 7⅜ inches. 7 Height, 7⅜ inches.

1. Flat circular stone. (Diameter, 17 inches.) 2. Stone ring with attached stone head. (Greatest diameter, 10⅝ inches.)

FIG. 3.—STONE OBJECTS FROM PORTO RICO AND SANTO DOMINGO.

the latter collections were generously placed at the disposal of the writer for study.

There still remain in Porto Rico many scattered prehistoric objects and one or two collections, among which may be mentioned that of Padre Nazario of Guayanilla. The owner kindly allowed the author to inspect this important collection, which contains many rare and unique objects.

STONE IMPLEMENTS.

Celts.—The so-called celts which, as a rule, are finely polished, pointed at one end, and sharpened at the other, are called by the country people, as above stated, *piedras de rayo*, or "thunder-stones," since they are believed to have fallen from the sky. Almost every household has one or more of these stones, which are thought to afford protection from lightning, or to be efficacious in the treatment of certain bodily disorders. The method employed by the natives to determine whether a stone is a "thunder-stone" or not, is to tie a string about it and put it in the flame of a candle. If the string burns immediately, the stone is not regarded as a true thunder-stone. About five hundred celts tested in this way and regarded by their owners as veritable thunder-stones were purchased. These celts are of many forms, from simple polished stones to well-made hatchets. Only one specimen of all those obtained in Porto Rico was provided with a groove for the attachment of a handle; in this specimen the groove was roughly pecked and was not polished like the remaining surface.

One of the implements collected resembles a double-edged ax; it is oval in form when seen in profile, has a rough surface, and is without a notch or groove for hafting. Several specimens show marks of surface pecking, but not of chipping, their present finish evidently having been produced by rubbing or polishing.

There are several flat, rough, double-edged stone implements, each with a notch cut on the opposite sides, evidently for the secure attachment of a handle. This variety of celt is well represented in the collections from Santo Domingo, but it has not yet been found in Porto Rico. None of these is smoothly polished and not one is petaloid in form. Other celts have a rough surface, and are pointed at one end and broad at the other, with a ridge marking the place of hafting. This type, which occurs more abundantly in Santo Domingo than in Porto Rico, recalls Carib implements described as having been found in the Lesser Antilles.

Several implements of soft stone are pointed at one pole and flattened to a cutting edge at the other. They have plane faces and rounded edges, thus differing from the next group, in which the faces are convex. There are no grooves or ridges for hafting.

The majority of celts are called petaloid from the resemblance of their profile to the petal of a flower. They are of all sizes and in some instances are made of stone either rare or unknown to the islands. The surface of these implements is convex and finely polished, and their forms show variation in the length as compared with the breadth. The cutting edge may be straight, slightly curved, or at an angle to the axis. In a few instances the "pointed" end is blunt, but in no case is there a groove or notch for the attachment of a handle. There is little doubt, however, that the celts were once provided with wooden handles, the stone having been inserted in a cleft in the wood and lashed with fiber or held with gum.

In the Archbishop's collection there are three celts with the blade and handle made of solid stone (Fig. 1). One of these is rudely fashioned, but another in point of finish ranks with the finest known examples.

Several writers on the archeology of the West Indies record the existence of celts with heads or bodies cut in low relief on the sides. A beautiful example of this work in the Archbishop's collection has a human head and a part of the body and arms cut on one face, as shown in Fig. 2 (3). This fine implement is termed a ceremonial celt on the theory that it was used in Antillean rites. It probably was not provided with a handle, which would have concealed portions of the figure in relief.

Chisels and Other Implements.—A number of stone chisels, used for incising the complicated designs on objects of wood or stone, were obtained in Porto Rico. These are cylindrical, and are either flattened to a sharp edge or pointed at one or both extremities. Some of these chisels have a cutting edge on one end and a point at the other, while others are blunt at one end with a point or an edge at the other. One of the chisels is perforated at the end opposite the sharp edge.

Other Stone Objects.—A stone implement, not belonging to the petaloid type of celts nor to the chisels, is of ovoid form which continues at one pole into a slightly curved extension that fits the hand so well as to suggest its use as a maul.

Another type of stone objects, possibly ceremonial, consists of a stone disk with a slender handle attached to the rim. The richly decorated specimen of this type in the Smithsonian collection [Fig. 2 (4)] was obtained in Santo Domingo by Mr. Gabb.

Two other stones [Fig. 2 (1, 2)], one hard and black, the other brown and of softer material, are flat at one end, with bifurcated tips to the handles. One may assume that these objects were used as rubbing or polishing implements. Handles with bifurcated tips occur also in stone implements from the Lesser Antilles.

One of the stones in the Archbishop's collection has a profile like that of a clam shell, the valve area having rounded projections. There is also in this collection a stone of melon shape, with meridian surface grooves which remind one of the ambulacral plates of a sea-urchin. The irregularity of these grooves and the artificially pecked surface stamp this object as an implement rather than as a fossil, which it somewhat resembles.

Some of the many stone balls found in Porto Rico, especially in ball courts or in streams, are undoubtedly artificial; but others are natural, water-worn bowlders. They vary in size from several feet in diameter to that of a marble. One of the smaller specimens, made of soft stone, has small pits at the opposite poles.

Among the problematical objects from Porto Rico are two white stones unlike any yet described. They are cylindrical, four and a half inches long by an inch in diameter, and perforated at each end in such manner as to suggest, at first glance, that they were strung together in necklaces. A similar stone object, somewhat better made and ornamented with a human hand carved in relief on the surface, was seen in the Nazario collection. The stone cylinders are symbolic, not decorative objects, and were carried in the hand for some unknown purpose. In his excavations at Utuado the author found a similar object made of bone.

Stone beads, of which there are many in the Imbert collection, in addition to the perforation through the axis, often have a smaller hole near the end, at right angles to this perforation, possibly for the insertion of feathers.

One of many problematical specimens in the Archbishop's collection is a large, flat, circular stone with a perforated extension on the rim [Fig. 3 (1)]. The author has seen another specimen, rectangular in shape, with two extensions, one on each angle of the same side. The use of these stones is unknown. It has been suggested that they were used to aid parturition, but there is no evidence to support this theory. One surface of the circular stone is decorated with a shallow, meandering groove; the other is without ornamentation.

Señor Imbert's collection contains a stone slab, a foot square, which the owner regards as a gaming implement. On each face there are six small pits arranged in two rows, and Señor Imbert believes that a pebble or other small object was placed under one or another of these pits and covered by the stone. It is supposed that, in playing the game, the opponent guessed under which depression the pebble was concealed, possibly indicating his choice by pointing at the corresponding depression on the upper surface. The author, having no other interpretation of the use of this slab, which is undoubtedly artificially worked and prehistoric, mentions this explanation more as a plausible hypothesis than as an exact determination of its use.

Stone Mortars.—Excavated stones, ranging widely in form and identified as mortars, were collected both in Santo Domingo and in Porto Rico. One of the best specimens, in the form of a shallow bowl, forms a part of the Archbishop's collection. Others are elongated or boat-shaped, and some have ornamented elevations on the rim.

In the Archbishop's collection, also, there is a flat stone slab with a shallow depression on one side as if designed to serve likewise as a mortar; but as the depression is perforated, it could not well have been used as such. It may have formed part of a primitive mill and have been used with an oval stone, flat on one side and convex on the other. The latter object, which has a pit in the middle and shallow grooves irregularly arranged in a radial direction on the convex side, may have served as a nether stone to the perforated slab.

Ornamented Stone Pestles.—The skill of the Antilleans in stone working is nowhere better shown than in the carvings on the handles of their pestles. These carvings are so well executed that the pestles are sometimes called idols, and it is indeed possible that some of them may have served as such. The majority, however, were household implements, and were designed purely for secular use, the figures cut on the handles being merely for decoration. So far as they have been studied, the carved pestles from Santo Domingo excel in finish those of the other West Indian islands, the Porto Rican examples being cruder and less carefully made. The Archbishop's collection contains several fine pestles with ornamented handles, many of which are adorned with human figures, having heads, bodies, and limbs beautifully cut. One of the best of these figures [Fig. 4 (1)] represents a human being lying on its back, with legs drawn up and hands resting on the knees. In another fine specimen the handle terminates in a carved human figure with legs drawn to the body [Fig. 4 (2)]. The opposite end of the handle of this specimen, where it joins the base, is surrounded by an incised broken line—an ornamental motive which constantly appears in Antillean pottery. The well-made pestle shown in Fig. 4 (6) has the head and body well cut on the handle, the arms and legs appearing on the sides.

The base of these pestles is ordinarily lenticular, but in the example shown in Fig. 4 (5), it is spherical; the whole handle is fashioned into a human figure, the head being well made, the legs sculptured in low relief but appressed to the body. There is a simple pestle in which the handle takes the form of a bird, the head and wings being well represented. Other collections from Santo Domingo contain pestles with bird-shaped handles, the ends of which are modified into rude heads.

IDOLS.

In order to show the position of idolatry in the primitive worship of the West Indians, a few words on the general nature of Antillean religion may be opportune. According to early writers the inhabitants of Santo Domingo worshiped stone, wood, and clay idols, called *zemis*. It is learned from the writings of Padre Roman Pane, Peter Martyr, Benzoni, and others, that the sun, earth, and other nature powers were also called *zemis*; therefore it is evident that the term was applied not only to idols, but to the spirits which they represented; thus the sky-god was called a *zemi* and its wooden image bore the same name, in which case the term was made to designate both magic powers and their personations, a custom universally followed in American religions. The Antilleans, according to the above authorities, likewise called their ancients or ancestors *zemis*, and sometimes gave the same name to their priests. Relics of the dead, as human skulls or other bones, images or idols, and other symbols or paintings of the same, were known as *zemis*. Each clan had, in the keeping of a chief, an idol or image of an ancestral *zemi*, the symbolism of which was characteristic of that clan. One Spanish writer declares that *zemis* are practically what Christians call angels—the immortal spirits of men. Here, also, the word refers to both the spirit and the personation—the magic power of the dead or an idol symbolizing or representing the same.

The worship of *zemis*, which practically included all supernaturals, gave rise to the use of a complicated system of objective symbols, idols, images, relics, and the like, each of which had a special and individual meaning. The idols were many and varied; they were made of wood, clay, or stone, and sometimes took the form of effigies of which the skulls or other bones of ancestors formed a part. There are representations of these various idols in several collections, but the present article will consider only those of stone, wood, and clay.

Stone Rings.—Among the problematic archeological objects from the West Indies none is more characteristic of Porto Rico than the so-called stone collars or rings. They are practically limited to Porto Rico and the immediately adjacent islands, and to the eastern end of Santo Domingo, for they have not been reported from Cuba, Jamaica, or the continent. There are approximately one hundred of these objects in the museums of Europe and the United States, and a few still remain in Porto Rico. To the Latimer collection, which in these objects is the richest in the world, the author has added eight specimens, some of which are unusually fine.

The use and meaning of the stone rings have given rise to much speculation, since historical records give no satisfactory clue to their function. These objects were apparently not mentioned by any chronicler contemporary with their use, and, indeed, they escaped notice until a little more than fifty years ago—three and a half centuries after the Indians had disappeared.

It has been conjectured that they were bandoliers worn by the caciques as insignia of rank, but some of them are too small for such purpose and others too heavy for a man to bear on his shoulders. The author believes that they were idols, and has therefore included them among the *zemis*. As an interpretation of what the objects represent, it is suggested that they are images of the coiled bodies of serpents or reptilian monsters which personated some great nature power, possibly a sky or wind god.

The heads of these idols, however, are not apparent, although no idol can be regarded as complete without the head. For this important part, which in all idols among primitive men is most carefully made, we look to another group of polished stone objects, also peculiar to the islands, in which the stone rings are found, viz., the masks and heads, called mammiform images, which have been figured by several writers on West Indian antiquities. These masks are supposed to have formerly fitted certain roughened surfaces on the stone rings forming the coiled bodies of the serpent, in the manner indicated in Fig. 3 (2). The arguments for and against this hypothesis, which was first suggested by Sr. J. J. Acosta in the notes to his edition of Inigo's Historia de Puerto Rico, cannot be given here, but will be considered more at length in other publications.

Idols with Conical Projections.—Among the stone objects in the Latimer collection, described by Prof. O. T. Mason,* occur certain tripointed specimens to which he gives the name "mammiform stones." These specimens, like the stone collars, have remained enigmatical up to the present time, but the true use of some of them, in the opinion of the writer, was, as above suggested, for attachment as heads to the coiled serpents or reptiles of which the stone rings represent the bodies.

Several of the tripointed stones bear representations of fore or hind legs on a projection opposite that which contains the head. The forelegs, when present, are cut on the sides of the conic elevation, while in the region of the shoulders are pits, which indeed are sometimes present even when there is no representation of limbs. In one or two instances there are two of these pits on each side. Some doubt arises whether these pits represent ears or shoulders, but their position on the legs corresponds with similar depressions sometimes found on the front legs of stools made in animal form. Possibly stone or shell ornaments were once inserted in these pits, in which case they doubtless represented ear pendants.

The fact that several of these tripointed stones have fore or hind legs cut upon them shows conclusively that in some instances they represent the complete bodies of idols, and were not fastened as heads to stone rings or other objects. An examination of the form of the head, and especially of the mouth, of these stones, reveals a similarity to corresponding parts of different animals, as fishes, lizards, and birds.

In considering the outlines of these tripointed stones it is found that, while preserving much the same form, they fall into several types. In the first type one of

* Latimer and Guesde Porto Rico Collections, Smithsonian Reports, 1876 and 1884, reprinted 1899.

the prominences is cut in the form of a head, while another represents the limbs or body, the conical prominence remaining unchanged. In another type all three prominences are without carving, but a face is cut between two of their projections, the legs either appearing on the side of the stone or being wholly unrepresented. In still another type the conical prominence is modified into a mouth or nose, giving the stone, in some instances, the form of a mask.

The Archbishop's collection contains a good specimen of the first type of these objects; there is a head on one projection, limbs on the other, and a conical protuberance between the two. Two specimens of this type from Porto Rico differ but little from those in the Latimer collection. One of the latter is of fine brown stone, the other of black basaltic rock. Both are smooth and well made, while the latter is one of the largest yet recorded. Another of the same type, made of white marble with yellow patches, may be considered the finest specimen in the collection obtained by the writer. Its conical process, instead of being pointed, is hemispherical, and the surface is decorated with incised geometric figures, among which the circle and triangle predominate. A small mammiform idol, also of the second type, is made of black stone with surface decorated with incised circles and other geometrical figures. This object shows superficial remnants of a black resin or varnish which possibly originally covered the surface of all these idols. A pit on the back of the conoidal projection recalls a similiar depression on the head of certain other specimens. Not all these stones of the second type have faces cut upon the conical protuberances; several were found which are perfectly smooth, although their forms are strictly the same as those on which eyes, nose, and mouth are indicated. One of these, which is very small and smoothly polished, is significant owing to the light which it sheds on the use of these stones. This I will shortly refer to.

The third type includes specimens in which the conical projection does not exist or in which its place is taken by the snout or mouth of an animal. The general form of this type is the same as that of the other mammiform images, having the slightly concave, rough under surface terminating in a prominence at each end, while the conical projection is replaced by a mouth or nose, recalling a form resembling a mask. In other words we have in these objects an intermediate morphological link between mammiform stones and masks, although more closely allied to the former.

Two specimens of this hitherto unknown type of idols occur in the Archbishop's collection. The first, made of light brown stone, has a shallow eye, an elongated mouth and forelegs cut on the sides in low relief. The second example is even more elaborately made, the details of the jaw being more completely worked out. In this specimen the forelegs are not represented, but the raised forehead and throat ridges peculiar to other mammiform images are well shown. The eye sockets are deep, the nostrils appear in relief, and there are superficial markings suggesting teeth.

In studying the form and position of parts of this type it is evident that it is practically the same as that to which belong the preceding two with conical projections on top of the head, so that any valid objection to a theory of the use of the objects belonging to this type applies also to the others.

The specimen next to be considered also has the tripointed form of the mammiform zemi, but it lacks the conoidal elevation, and in that respect is more like a mask. It resembles the third type, or the two specimens last mentioned, except that the mouth, instead of replacing the conical elevation, is situated on one side, the nose being extraordinarily flattened. This specimen, like the last two, came from Santo Domingo; it was purchased from Sr. Zeno Gandia and formerly belonged to the Gabinete de Lectura at Ponce, Porto Rico.

The author also purchased in Porto Rico a rude stone head, resembling in certain respects the one last mentioned, but differing from it in having a projection at the top. A corresponding protuberance forms the neck, suggesting that the stone may have been lashed to some other object, such as a stone ring. A beautiful stone of the third type, in which the nose takes the place of the conoid projection, was purchased from Señor Gandia. Its lower, slightly concave surface has been fitted to one of the Porto Rican collars, as shown in Fig. 3 (2).

In the absence of information regarding the use of these tripointed or mammiform stones here identified as idols, it has been suggested that they were merely highly ornamented mortars, the object when, in use being reversed—the conoidal projection being inserted in the ground for stability, and the slightly concave surface thus brought uppermost. This theory is advocated by Im Thurn, a generally excellent authority on account of his intimate knowledge of related tribes.

But if this supposition be correct, why, it may be asked, has so much care been given to the ornamentation of the conoid prominence in the third type, which would be buried in the earth? It may also be pertinent to call attention to the tripointed stones with perfectly smooth surfaces, and particularly to one which is barely half an inch in length. Certainly these are not adapted in size for grinding implements, and their superficial polish would also seem to prohibit their use as such. It is evident that at least the small and smooth tripointed stones were not used as mortars, and as their form is practically the same as that of the larger ones, although the latter have a rough surface, it is doubtful if either type was used for grinding.

A direct statement by Ramon Pane regarding different forms of zemis should have great weight in determining the significance of these stones. He says that the Haytians had a form of zemi with "three points," evidently referring to some of the tripointed stones above mentioned. This writer also states that this form of tripointed objects was believed to make the *guica* grow.

Stone Disks with Faces on One Side.—Two specimens of stone disks, bearing faces, are contained in the collection from Porto Rico. Although in their general outline they resemble the so-called masks of other authors, they differ from them in some particulars. It is possible to interpret them as symbolic masks, but while they could not have been worn over the face, they may have been attached to staves and set in mortuary mounds or carried in processions during the rites attending ancestor worship.

A rough stone, convex on one side and flat on the other, on which is a well-cut face, was purchased from Sr. Zeno Gandia, and a somewhat similar stone, a part of the edge of which is broken, was collected by the author in the mountains near Utuado, Porto Rico.

A small head with a part of the body occurs in the Imbert collection at Puerto Plata; it is of finely polished syenitic rock, and the eyes, nose, ears, mouth, and teeth are unusually well made. This object was evidently an idol.

The Archbishop's collection contains a stone which, when viewed in profile, is seen to be trilobate, having a median projection flanked on each side by smaller ones. The middle projection has three depressions so arranged as to suggest eyes and mouth. This object is provisionally regarded as a crude idol of the mammiform variety, but it bears no resemblance to the tripointed forms.

Another stone head in the Imbert collection is spherical in form and has an extension at each pole in which there is a slight depression. The eyes, nose, and mouth are represented in relief; but the remarkable feature of this specimen is three "wens" or knobs, one on the forehead and one on each temple. This head was found in the ruins of old Fort Santo Tomas, Santo Domingo, and was presented to Señor Imbert by José Roman Perez.

In a collection of prehistoric objects once the property of the late Dr. Llenas, of Santiago de los Caballeros, but now owned by his son, there is a similar specimen which should be mentioned in connection with the one last described. This is a stone ball like those so constantly found near the *juegos de bola* of Porto Rico, having the surface smooth with the exception of three knobs arranged in a triangle at one pole. Unlike the Imbert specimen, however, no face is carved upon it.

(To be continued.)

THE LIFE-HISTORY OF RADIUM.*

IN a letter under the above title in Nature of May 5, Mr. Whetham brings forward some results dealing with the hypothesis that radium is being produced from uranium. May I be permitted to state that I have been engaged during the last twelve months in an experimental examination of this hypothesis? In the paper in which the suggestion was made that radium may be being formed by the disintegration of a parent element possessing heavier atomic weight (Rutherford and Soddy, Phil. Mag., May, 1903, p. 587), this sentence occurs: "The point is under experimental investigation by one of us, and a fuller discussion is reserved until later." Mr. Whetham's letter makes it desirable that the results that have been obtained during the past year should be published.

Twelve months ago I purified a kilogramme of uranium nitrate until the quantity of radium present was less than 10^{-13} gramme. This was the limit of detection by means of the electroscope employed, using the maximum or equilibrium amount of accumulated radium emanation as the test for the presence of radium. It was arrived at by direct comparisons with the emanation from a standard milligramme of radium bromide, by subdivision until its presence could no longer be detected. Unfortunately, owing to the large amount of radium in the laboratory, subsequently introduced for the purpose of the helium research, the electroscopes have been affected, and it is not possible at the present time to be sure of such minute effects as originally. But it may be stated that less than 10^{-11} gramme of radium has accumulated in the kilogramme of uranium during the past twelve months. This practically settles the question so far as the production of radium *from uranium* is concerned.

In a paper read recently before the Royal Society by Sir William Ramsay and myself, an experimental determination of the rate of change of radium was given. It was shown that rather less than one-thousandth part changes per year. The rate of change of uranium may be taken as a million times slower, since its radioactivity is a million times less; so that, in one kilogramme of uranium nitrate, about 5×10^{-7} gramme would change per year. The quantity of radium produced was less than 10^{-11} gramme, so that the conclusion is arrived at that if uranium changes into radium, less than one-ten-thousandth part of the theoretical quantity is produced during the first year's accumulation.

The result, of course, may be explained by assuming the existence of intermediate forms between uranium and radium. But from a general consideration of the whole question from the point of view of the disintegration theory, several such hypothetical forms, each with an extended life, must be assumed. So that unless modifications are made in the theory, which at present are not justifiable, the evidence may be taken as indicating that uranium is not the parent element of radium. The experiments will be continued from year to year with the kilogramme of uranium nitrate. But as I am leaving England immediately, and shall be away several months, I take the opportunity of presenting the results of the unfinished research, and hope at a later date to give a fuller account.

FREDERICK SODDY.

University College, Gower Street, W. C.

In their communication to the Royal Society of April 28, Sir William Ramsay and Mr. Soddy by direct measurements determine the rate of decay of radium as one thousandth of the mass per annum, giving as the average life of the radium atom about one thousand years.

This rapid rate of decay, of course, renders it quite out of the question to assume that in the radium now existing on the earth we are dealing with the residue of a larger quantity reduced by decay to its present amount. If we carry backward so great a rate of change we, in fact, arrive at the existence of such large amounts quite a few thousand years ago as to postulate a red-hot earth almost within historical times. We are thus either compelled to assume that the rate of transformation observed does not apply generally to terrestrial radium, but only to radium separated by chemical treatment from pitchblende, or that the existing store of radium is derived by steady supply from some substance of greater atomic weight. The first hypothesis, in view of what is known as to the intimately atomic nature of radio-activity, may be dismissed.

That the probable source of radium is uranium is advocated by Prof. Rutherford in his book on radioactivity. From a conversation with Sir Oliver Lodge I gather that he also considers this not improbable. The reasons for it need not be given here.

Now if radium is derived from pitchblende, the rate of change of radium is a measure of the rate of change of pitchblende, supposing a steady state of supply and loss has been attained. This last condition I think we are entitled to assume, although doubtless from the mathematician's point of view a perfect equality would be improbable. But I will quote Prof. Rutherford ("Radio-activity," p. 334): "Since radium has a short life compared with that of uranium the amount of radium produced should reach a maximum after a few thousand years when the rate of production of fresh radium—which is also a measure of the rate of change of uranium—balances the rate of change of that product."

Let us now assume as an approximation that from 1,000 kilogrammes of uranium the yield of radium under the most favorable conditions would be one decigramme. It may here be observed that the fact of pitchblendes varying in their content of radium is only what is to be expected under the conditions of preservation of the ore, exposed as it is to chemical attack, or, as Prof. Rutherford points out, to the action of percolating water. We have in seeking to learn the content of radium for our present purpose to take the maximum observed.

The one decigramme of radium transforms into substances of lesser atomic weight at the rate of one-tenth milligramme per annum. Now this is also the annual supply from 1,000 kilogrammes of uranium. In other words, the uranium breaks down at the rate of $1\text{-}10^{10}$ part of its mass per annum. The average life of the uranium atom is according to this ten thousand million years.

In determining this average life from so short a period of observation, we, of course, make the assumption that the death rate observed is an average one, and that a steady state is attained truly founded on the mean longevity of a vast number of individuals of varying ages, varying rates of loss of corpuscular temperature as well as of varying amounts of initial corpuscular energy, such conditions as would attend material evolution according to Prof. J. J. Thomson's fascinating book "Electricity and Matter." Similar assumptions must be made before we could deduce the average longevity of a vast population from a short period of observation of the death-rate.

On these assumptions an interval of time is indicated which may be considered a minor limit to the antiquity of matter in our part of the universe. For if the average life is really 10^{10} years, must we not assume that some of the atoms now expiring as uranium were existing ten thousand million years ago? Geological time, as we guess it, is but little more than a moment in the being of so great an era—as thirty-six seconds is to an hour.

Whether we will ever be able to obtain direct *proof* of so remote an antiquity is impossible now to say, but it is remarkable that the rate of change of thorium to thorium X affords the same average longevity for the atom of thorium as we arrive at on the data above for uranium, or again from the known rate of change of uranium to uranium X. Thus Rutherford gives 10^{-16} to 10^{-17} as the change-rate per second to thorium X. The change-rate 10^{-10} for a year's disintegration will be found to lie between these limits. J. JOLY.

Trinity College, Dublin, May 1.

* Nature.

Hitherto the utilization of acetylene gas for commercial utility has been distinctly limited to such purposes as lamps for cycles, automobiles, and other vehicles, or for small lighting plants. In England, however, an attempt is being made to substitute it for coal gas upon a practicable and extensive scale. The Board of Trade has granted permission to a company to manufacture and supply acetylene gas for lighting purposes

in both the streets and residences in Elham (Kent) and adjoining villages. The illuminating qualities of acetylene gas are greater than the ordinary coal gas generally employed, and almost equal electricity, while its cost of production is but moderate. This experiment to adapt this gas to commercial lighting purposes is being followed with great interest, and should it prove successful will probably be extended to other parts of the country.

PURIFICATION AND COMBUSTION OF ACETYLENE.

Crude acetylene, as produced by even the most improved apparatus, is always impure. In fact, lime and carbon, the crude materials that are used for the manufacture of calcium carbide, always contain foreign substances in varying quantity that are found again in the gas in other forms, and, in the applications of the latter, occasion various inconveniences, some of which are very serious. Among the impurities, the two principal ones are phosphureted and sulphureted hydrogen. One of these gases, in burning in contact with the air, gives rise to phosphoric acid, and consequently to characteristic deleterious white fumes and a very disagreeable garlicky odor, and the other to sulphurous acid, the pernicious effects of which, from the viewpoint of health, are well known.

Crude acetylene, as manufactured in certain apparatus, contains, in addition, as a consequence of inadequate washing, some ammonia and some tarry products, resulting from a production at too high a temperature. Finally it carries pulverulent lime along with it. Each of these bodies, according to its properties, contributes toward injuring gildings and paintings, oxidizing metal objects, discoloring fabrics, tarnishing windows, and, finally, fouling the burners used for the combustion of the gas.

All such inconveniences are of a nature to make a perfect purification of the gas obligatory. Among the processes that have been proposed, that of Professor Ullmann, of the faculty of Geneva, is remarkable by its simplicity. By means of a single product, he economically effects the elimination of all impurities with apparatus that occupy but little space, and by manipulations that can be performed by any one.

Fig. 1.—ACETYLENE STOVE.

This product, which has received the name of "heratol," was found by Prof. Ullmann after experiments which demonstrated to him that, contrary to the opinion generally held, acetylene is not decomposed by chromic acid. Heratol is a yellow powder very permeable to gas and composed of two elements—a porous material and a solution of chromic acid with which the material is saturated. This powder is placed in a purifier (Fig. 1) interposed between the generator and the piping. When the gas traverses the purifier, the phosphureted and sulphureted hydrogen take from the chromic solution the quantity of oxygen necessary to convert them into basic salts of chromium. The ammonia is neutralized by the acid, and the tarry products and pulverulent lime are retained in the pores of the material. Upon becoming exhausted, the heratol gradually changes color as a result of the production of salts of chromium, of which it assumes the characteristic green color.

This change of color permits, through the glazed sight-holes with which the purifiers are provided, of ascertaining the moment at which the latter should be recharged. From a communication made by M. E. A. Jarral to the Union Française des Acetylenistes on July 2, 1902, it appears that heratol prevents the fouling of burners so thoroughly that a tip placed under observation showed, after more than two thousand hours' use, no trace of fouling or deterioration, while with other purifying materials such would have been far from being the case. In support of his assertion, the author sums up in a graphic table the results of the comparative tests that he made, simultaneously and under conditions at every point identical, of heratol and the two best purifying materials known. An examination of this table shows that with heratol the diminution of the discharge, or, in other words, the fouling of the burners, is null, while at the tenth hour it is very perceptible with the material with chromate of lead as a basis and is exceedingly marked with the material with chloride of lime as a basis.

It does not suffice that the acetylene shall be properly purified, for it must also be used in proper burners. In fact, what we have to deal with is a hydrocarbon exceedingly rich in carbon, and, in order that its combustion shall be perfect, it is indispensable that the air shall reach the flame in sufficient quantity to prevent the oxygen (burning at first a portion of the carbon) from becoming free and rendering the flame smoky. It is indispensable also to prevent the orifice of the burners from reaching the temperature at which the gas, having become decomposed in contact therewith, would deposit particles of carbon that would gradually clog them up.

These two difficulties are surmounted by means of twin air-drawing burners, known by the names of Bullier, Naphé, and Dollan burners. These consist of a combination of two tips placed in such a position that the jets of gas meet each other nearly at a right angle. Each of these tips consists of a small orifice followed by a second one of wider section, isolated from the first by a space which the air freely enters. The gas escapes from the first orifice, carries along with it (or more likely around it) a certain quantity of air through the second orifice, as a consequence of which the combustion occurs in a round jet. The two jets unite in meeting each other and the flame assumes the form of a butterfly that presents a wide surface in contact with the air, and this assures the combustion of the last traces of carbon. On the other hand, the air carried along forms an isolating mattress that prevents the heat due to the combustion from being propagated up to the emission orifice. According to the author of the communication above mentioned, the same results are obtained when perfectly pure gas is employed with twin burners, without the carrying along of air, and constructed according to the directions which he gives.

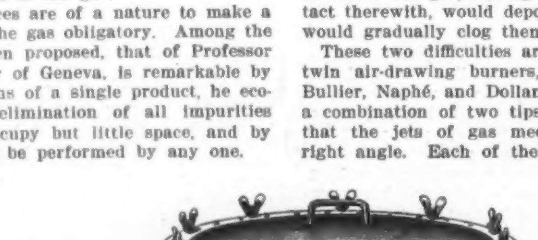


Fig. 2.—ACETYLENE PURIFIER.

The combustion of acetylene in apparatus designed for heating, also presents genuine difficulties, and the first apparatus devised possessed such inconveniences that it seemed doubtful whether it would ever be possible to succeed in practically utilizing the great heat produced by a mixture of acetylene and air. At the moment of lighting, there was obtained, indeed, a heating flame characterized by a blue color, but this flame quickly became white and then smoky. This change, induced principally by the heat being communicated from the burners to the orifices serving for the introduction of air, caused the expansion of the latter, which, consequently, was no longer carried along by the gas in sufficient quantity. There exists at present certain acetylene heating-apparatus that operate as satisfactorily as do ordinary gas heating ones. In the stove represented in Fig. 1, the diffusion of the heating is prevented by a wide surface in contact with the air formed by a radiator with flanges, and by placing the burners at a distance from their support. This stove presents an interesting peculiarity which consists in the prevention of back firing without having recourse, as has hitherto been thought indispensable, to the interposition of wire cloth, the least of the drawbacks of which is that of requiring frequent cleaning. The great progress that we have just pointed out would alone suffice to explain the rapidity with which the use of acetylene is gradually extending. In fact, owing to its purification, and to the improvement of the burners, as well as to the applications of this gas to heating, it is at present rendering the same service as coal gas, than which it has the advantage of being cheaper and of furnishing a more agreeable light and a more intense heat.—Translated from La Nature for the Scientific American Supplement.

CONVERSION OF PLASTER OBJECTS INTO IMITATION IVORY, MARBLE, WOOD, AND BRONZE.

The art of changing the appearance of decorative plaster objects seems to interest many readers. We will give a few easy processes for obtaining quite artistic effects. We have seen statuettes, low and high reliefs, medallions, medals, and copies of rare coins, which could scarcely be distinguished from the genuine. Before attempting anything important, we advise experiment with small pieces, in order to master the *modus operandi*. With wood or bronze, the want of success in imitation is not irreparable. It is sufficient to wash the pieces, where there has been a failure, with a pad of wadding soaked freely in spirits of turpentine; or in obstinate cases recourse can be had to washing with potash, followed with thorough rinsing in clear water.

Ivory.—Cut white wax into thin pieces, and put these in clear spirits of turpentine. Melt on the water bath. The solution should have the consistency of a thick syrup. If it is too thin, add a little wax; if too thick, add turpentine.

If white ivory is to be imitated, use the solution as it is. If the yellowish color produced by time is desired, or if the piece is somewhat damaged, it is necessary to trace, say with a needle, which can be mounted in a handle, some striæ on the object, and add to the solution small pieces of yellow wax till the desired color is produced. If the object copied is really of ivory, nothing is easier than to have two solutions, one white, the other slightly colored, in order to combine them according to the shade of the model.

Three layers are given to the plaster by soaking in this solution, applying it hot, in order that it may penetrate better, with the aid of a soft brush, or better, with a pad of wadding fixed at the end of a rod. After each application, allow an interval of time sufficient for the evaporation of the turpentine so far as possible. The soaking should also be as regular as possible.

When the third layer is dry, if the appearance of old ivory is desired, make with a flexible knife, on a plate of glass, a mixture of linseed oil and yellow ochre or burnt sienna, and pass this mixture through the hollows, and in case of imitating extreme oldness, into the striæ. The piece is then to be wiped, where the mixture has been placed, with a piece of flannel.

To give the polish and brilliancy of ivory, it is sufficient to rub the object with a pad of wadding, charged with talc powder, then with a piece of flannel. The talc powder should be used before the third application of wax and turpentine is dry, or the result will not be good.

Marble.—Immerse the plaster object, when clean and dry, in a solution of alum, composed of 650 grammes of alum and three liters of water, or in this proportion. The solution is made hot until the alum is all melted; the plaster is plunged into it while the liquid is still hot. In half an hour it is taken out, and placed on two sticks over a receiver, in order to drain. It is allowed to cool, and then wet as regularly as possible with the liquid, to facilitate a new moistening with a pad of wadding. The operation is stopped as soon as the alum has deposited its crystals over the whole surface; then the article is to be placed on a dry spot and left there until all of the moisture has disappeared. In a few days it should be rubbed with very fine sandpaper or emery-paper, and the operation ended by rubbing with a slightly moistened cloth.

Wood.—Different colorants may be employed for wood, according to the shade desired.

1. If a very fine powder giving a nutshell color can be procured of a druggist or dealer in colors, mix it with linseed oil, spirits of turpentine, and a small quantity of a drier in proportion varying according to the color desired.

2. Mix Cassel earth with the above, which will imitate old oak with its different shades, according to the quantity used.

3. Melt on the water-bath glue that has been previously broken with the hammer, with the nutshell powder, which is furnished prepared, and is used by cabinet makers for coloring whitewood. But little glue should be used, so as not to thicken the solution too much. It is to be applied hot with a brush, and several coats given, according to the result sought.

The nutshell preparation may be made by the operator in the fruit season by boiling the outer green covering in water and adding to it a few drops of litharge (8 or 10 per liter) for a mordant. The litharge is to be added to the hot liquid only when the shells of the nuts have been pressed and taken out.

4. Stains for wood are found prepared in bottles, and may be used for imitating plaster.

One or other of these four processes may be employed. The plaster may be colored with the brush in the direction imitating the veins of the wood. If the wood is to have deeper veins in certain spots, suitable marks may be made with the brush in the right direction. For presenting the appearance of old wood, before coloring the plaster, it should be worked with the point of a pen-knife to imitate the deep fissures of old wood, hollows, or cavities left by the pieces detached by worms, etc.; a gimlet will simulate the worm holes. These may be left as they are, or the holes stopped up with wax. We have seen a plaster statuette, in which pieces of real wood and pins had been inserted, aiding the illusion produced by the coloring.

Bronze.—Metallic powders of all shades can be readily procured of druggists or dealers in colors. The following processes can be applied to the whole series of bronzes, florentines, burnished, deadened, oxidized, patinated, etc., as well as to yellow and red golds, new or antique, to silver, to tin, and if necessary to lead and zinc for outside decorations. The latter should be made with oil, and afterward varnished.

1. Break up strong glue, and melt a few pieces on the water bath, with sufficient water to produce a rather thick solution. Give three layers with the brush, so as to soak the plaster, and allow each layer to dry. Add a little plumbago to the second layer.

On a plate of glass used as a pallet, mix with a flexible knife bronzes of different shades until the desired color is produced, with linseed oil, spirits of turpentine, and a drier. Apply with the brush, darken the hollows, and light up the projecting parts, then let dry.

Afterward, on the same glass plate, mix in the same way red chalk and plumbago. Do not use too much drier, which would tend to crack the covering or produce a disagreeable reticulation. In general three parts of oil, one of turpentine, and one of drier should be used.

This mixture is designed to imitate bronze patina. It is to be applied only after complete drying and burnishing of the bronze. The burnisher is passed over the whole surface of the piece, pressing it sufficiently to crush the metallic grain, but not enough to break the weak parts of the plaster. The marks of the burnisher should be as nearly invisible as possible. When the patina has been produced, the object is to be wiped with a piece of flannel, in order to lighten the projecting parts; omitting the hollows, which are to remain dark. It is allowed to dry, and then varnished, if desired.

2. Give to the plaster a coating of linseed oil and drier (but little of the drier). When this coat commences to be sticky, which can be ascertained by applying the finger, the metallic powder can be added with a pad of wadding.

A green powder, called "Verona earth," may also be mixed with the oil, and put only upon the salient parts of the imitation bronze. This is an economical process.

3. Pass over the plaster a coating of linseed oil, mixed with English red. Dry, and put on a second coat, which should also be allowed to dry. Prepare a varnish by dissolving 65 grammes of shellac, finely broken, in 120 grammes of alcohol. Shake frequently. Dip a brush into this mixture and then in a cup containing the metallic powder, in order to charge it with this material. Apply the whole uniformly on the plaster.

If the objects are to be exposed to moisture, only processes with oil should be employed, and for the first receipt the three layers with glue may be replaced with three others with boiled oil.

All these operations should be made on plasters perfectly clean and free from grease; otherwise, the surfaces should be well coated with benzine.

Method of Cleaning Plaster Objects.—For removing dust and other substances that have been deposited on the plaster, which by rubbing might penetrate, it is needful to coat the surface with a rather hard brush, charged with starch paste. The starch powder, finely pulverized and quite white, is to be made into a thick paste with hot water, and applied freely when hot. It is left to dry slowly. The starch will split and scale off under the action of the nail, and the fragments, when detached, will bring off the soiled portion of the plaster.

Waterproofing of Plaster.—It is pleasing to ornament the corners of the garden or paths with statues. Bronze and marble are quite dear. Fortunately, plaster objects are sold at low prices. To protect them against the effects of the weather, they may be coated with boiled oil, which will be rapidly absorbed and the surface remain deadened. Then litharge, about one-tenth of its weight, can be added to the boiled oil, and the plaster objects will brave the worst weather.

If the terra-cotta color communicated by the oil is not desired, the statues can be bronzed by any of the processes previously spoken of, and varnished if desired.—Translated from Cosmos.

SPERMACETI REFINING AND MANUFACTURE.*

By CHARLES H. STEVENSON.

SPERMACETI is the solid portion of the crude oil of sperm whales and of certain other cetaceans. As noted in the chapter on sperm-oil rendering, it occurs in a state of solution in special cavities of the skull and to a much less extent in various parts of the body, especially in the core of the dorsal hump. The process of its extraction and the separation of the oil therefrom have already been noted in the account of rendering sperm oil, and it now remains to describe the subsequent treatment of the crude and refined spermaceti.

After the extraction of the "taut-pressed oil" the crude spermaceti is heated in vats or tanks, refined, and "whitened" by the introduction of some alkali, as a weak solution of caustic soda or caustic potash, to saponify any adhering oil. Care must be taken during this process that the spermaceti does not saponify, any tendency to do so being overcome by the addition of brine. The refined product is then molded into suitable shapes for marketing. Most of it is formed into blocks measuring 10 by 12 by 14 inches, and weighing about 62 pounds each. It is also molded into cakes weighing 1 pound, half-pound, quarter-pound, or of any other desired weight.

SPERMACETI REFINING. VAT FOR BOILING AND REMOVING SEDIMENT.

It is not easy to adulterate spermaceti without detection, since its characteristic properties are readily diminished, the compound being harder, with decreased nacreous luster and smaller foliated crystals. Tallow is readily detected by the odor given off in melting, and also by the compound making fat stains on paper, which is not the case with pure spermaceti. Stearin renders it harder and smaller foliated, and its presence is readily detected by boiling the sample in a soda solution, effervescence occurring in the adulterated article. If exposed to the air for a long time spermaceti becomes yellowish and somewhat rancid, but when remelted and treated with diluted caustic soda or potash it regains its original condition.

In the early history of the sperm-whale fishery spermaceti was considered of great value for medicinal purposes, and was recommended for many ills of the body, but was employed principally for internal applications, especially in cases of inflammation. It was so much in demand before the full development of the fishery as to sell at times for its weight in silver. As it became better known, however, it occupied a minor position in materia medica, chiefly in the preparation of ointments, and its principal use was in candle-making.

The beginning of candle-making in America dated from about 1750. The number of factories increased rapidly, and in 1761 there was a total of eight in New England and one in Philadelphia. In 1772 the first candle factory was established at Nantucket, then the headquarters of the whale fishery, and the number increased until there were ten in existence on the island in 1792, and an equal number then existed at New Bedford.* The business of preparing spermaceti was then separate from the general whale-oil refining industry, the candle-makers purchasing the crude head matter only. But gradually the two industries were combined to their mutual advantage.

PACKAGES OF BLOCKS, CAKES, AND CANDLES OF SPERMACETI.

Spermaceti is white, semi-transparent, unctuous or talcose to the touch, of a slight fatty taste and odor. A fracture of a cake reveals broadly foliated, crystallized pieces resembling quartz. According to Brannt, its specific gravity is 0.943 at 59 deg. F. It yields nothing to water, and very little to cold alcohol, but is readily soluble in ether, chloroform, and bisulphide of carbon. It melts at about 125 deg. F. and congeals immediately below the melting point. Its component parts, according to the same chemist, are carbon, 80.03 per cent; hydrogen, 13.25 per cent, and oxygen, 6.72 per cent.

When the sperm-whale fishery developed to its full capacity, the production of spermaceti was very large, averaging more than 3,000,000 pounds annually from 1835 to 1845. With the decrease in extent of the fishery, there was a corresponding decrease in the yield of spermaceti, reaching its lowest product in 1890, when less than 200,000 pounds were prepared.

Spermaceti is among the very best materials for candle-making, the product being beautifully semi-transparent and nacreous, burning with great regularity and with white light of high illuminating power; yet owing to the cheapness of other materials, espe-

* From United States Fish Commissioner's Report for 1902.

* New Bedford Medley, Nov. 30, 1792.

cially paraffin, only a small percentage of the candles used at present are made of this material. To reduce the tendency of spermaceti to crystallize in molding and consequently lower its friability, it is customary to add a little paraffin wax, tallow, stearin, beeswax, or cerasin. The clear natural color of the refined spermaceti is usually preferred in candles, but sometimes coloring material is introduced, in so small a quantity, however, as not to destroy the transparency of the spermaceti. A yellow tint is imparted by adding gamboge, a red by carmine, and a blue by prussian blue. Owing to the cheapness and excellence of paraffin candles, the consumption of spermaceti in candle-making has been greatly reduced. The quantity thus used at the present time bears no relation to the extensive use of petroleum wax for that purpose, the consumption of which in Great Britain alone amounts to upward of 50,000 tons annually.

Sperm candles are at present the standard used by the principal gas-examiners for photometric measurements. The rules for the preparation of standard sperm candles for photometric purposes, published by the Metropolitan Gas Referees, of London, prescribe that, for the purpose of rendering the spermaceti less brittle, best air-bleached beeswax, melting at about 144 deg. F., shall be used exclusively, and that the proportion of beeswax to spermaceti shall not be less than 3 per cent nor more than 4½ per cent; the spermaceti itself to be so refined as to have a melting-point lying between 112 deg. and 115 deg. F.*

The production of spermaceti in 1901 in the United States was about 400,000 pounds, worth $100,000. Of this amount probably 70 per cent was exported to Germany, England, and other foreign countries. Its principal foreign use is in the making of candles, large quantities being made in England and Germany for ecclesiastical use, especially in southern Europe. Minor uses are as an ointment for medicinal purposes, in laundries for producing a polish on linen, and for self-lubricating cartridges. Of the domestic consumption, probably 5,000 pounds are used in candle-making and the rest for medicinal and industrial purposes.

During the year 1901 the value of spermaceti greatly decreased, sales during November being made at 22 cents per pound, the lowest price reached in the last ten years.

CONTEMPORARY ELECTRICAL SCIENCE.†

Symmetry of Electrotherapeutic Effects.—It sometimes happens in the medical applications of electricity that the current has to be successively applied to the two arms or legs of a patient. During such operations H. Bordier has noticed a diminution of resistance in the limb not subjected to the current. Take the case of a patient whose right arm is galvanized by applying an electrode of 100 square centimeters to the right shoulder, while his front arm is plunged into water heated to 38 deg. and containing a carbon electrode. If now the current is brought up to 20 milliamperes, it is observed to increase gradually to, say, 24 milliamperes within 10 or 15 minutes, after which it remains constant. If then the left arm is similarly galvanized, there is a similar increase of intensity, but it attains, say, 30 milliamperes instead of 24. A further experiment shows that there is a corresponding diminution of resistance of the left arm. Its resistance in one case was reduced from 3,855 ohms to 2,962 ohms by the galvanizing of the right arm. The author finds an explanation in the fact that the resistance is controlled by the vaso-motor nerve centers in the bulky medullary axis, and that these centers, once stimulated, would produce a simultaneous and symmetrical effect on both sides.—H. Bordier, Arch. d'Electr. Med., October 15, 1903.

Permeability of Iron Powder.—The magnetic permeability of iron wire in alternating fields is known to depend largely upon the frequency. At a frequency of a million per second it is about 1-10 to 1-30 of its normal value in a steady field. This is usually explained by supposing that at such high frequencies the magnetization can no longer follow the field. But J. Zenneck has discovered that a similar inability is not shown by iron powder, whose permeability is nearly the same at a million per second as it is in a steady field. The author used two Leyden jars feeding two equal coils, in one of which the iron powder was placed. The difference of inductance between the two coils was measured by the spark potential between them. The powder was either used loose or embedded in paraffin. The greatest variation of the permeability observed amounted to 30 per cent, which is in marked contrast to the 90 or 96 per cent found in iron wires.—J. Zenneck, Ann. der Physik, No. 12, 1903.

Ionic Theory of the Arc.—J. Stark writes an elaborate essay on the electric arc from the point of view of the ionic theory which has hitherto been imperfectly applied to it. To simplify matters, he starts from the mercury arc, which is longer than the carbon arc, and shows more clearly the four constituent parts of the arc—viz., the brilliant brush issuing from the white-hot depression in the cathode, the dark space, the positive light column, and the anode layer. The glow discharge does not necessarily involve the evaporation of the cathode, but the arc light does. It is not essential that the anode should emit vapor. In all gaseous discharges one has to distinguish between electrons, positive atomic ions, and molar ions. In the Bunsen flame, the negative electrons play a very prominent part. In the arc, with its higher temperature, they are even more predominant. This is shown by the susceptibility of the arc to magnetic deflection and the readiness with which it follows every variation in the current, owing to the great mobility of the electrons. The impact of the electrons produces positive and negative ions from neutral molecules at the anode and in the positive light. The converse only takes place in the glow discharge, whereas in the arc the negative electrons are produced from the cathode by electrification, and not from the gas by ionization. The ejection of electrons from the interior of the cathode is partly favored by the presence of ultra-violet light, but most of all by the high temperature of the cathode. This high temperature produces in the interior of the metal an electric force driving the electrons toward the anode.—J. Stark, Ann. der Physik, No. 12, 1903.

* Journal Society Chemical Industry, 1894, p. 65.

† Compiled by E. E. Fournier d'Albe in the Electrician.

ELECTRICAL NOTES.

While in the first arrangement used by Marconi—a simple rising aerial conductor with spark gaps and earthed connections—the charge did not present any technical difficulties on account of the low capacity of the sending wire, the necessity of devices susceptible of furnishing high amounts of electricity has been felt since the adoption of the Thomson oscillation circuit as an exciter of the sending wire. Dr. G. Seibt (Elektrotechnische Zeitschrift, No. 14, April 7), while engaged in experiments in this direction, altered within very wide limits the capacity of the exciting circuit, when the efficiency of the induction coil was found to show a maximum as to spark length and spark quality for a given capacity load. A further investigation of this phenomenon disclosed some valuable results as to the design and operation of induction coils. In the first place, it was shown to be suitable to establish a loose coupling between the primary and secondary circuits, and to adjust for resonance between the own vibration of the arrangement and the excited vibration. The theory of these improved induction coils, or "resonance transformers," is further considered in the present paper.

In a paper recently presented to the French Academy of Sciences, M. A. Blanc records his investigation of contact resistance in a coherer consisting of a steel plate and a steel ball, the surfaces of which were carefully polished. The steel plate was supported by a rigid rod, and the ball by a flection spring, so as not to touch the vertical plate in the vertical position of the spring. The contact was established by inclining the apparatus, when the spring was bent merely by the weight of the ball. The pressure could be controlled readily by altering the inclination. If the apparatus be protected against any intense oscillations, a resistance up to 10,000 ohms and more was produced in this way. On suddenly completing through the coherer a current of a given intensity, the resistance, starting from a certain value, would decrease continually for some hours, first rapidly and then more slowly, and seemingly tending toward a limit. This progressive fall of resistance under the action of the current is termed by Mr. Blanc *coherization by the current*. The fall in the resistance due to coherization is irreversible, persisting even in the case of the current ceasing to pass, and being the greater and the more rapid as the intensity of the current increases. Small shocks will accelerate the phenomenon. If the coherization be nearly completed for a certain intensity, it is completed entirely for lower intensities, whereupon the resistance becomes very stable. If, however, the intensity be increased, another coherization is produced, the limiting value of the resistance being the same as in the case of the actual intensity being established suddenly. For medium intensities of this current, there is a region of maximum sensitiveness. Before any coherization has been produced, the contact resistance appears to be inversely dependable on the intensity of the current traversing it, decreasing for increasing intensities. For a slight coherization being nearly completed, the resistance is found to vary inversely as the intensity. For a high coherization, the direction of this variation is altered, the resistance decreasing for decreasing intensities. Between these two limits there is a degree of coherization for which the resistance is constant, i. e., for which Ohm's law is available exceptionally. The same results are obtained in the case of the coherization being produced by a spark. For a given intensity, while breaking and next making again the circuit, the current will not have any appreciable effect. In the beginning of the coherization, each reversal will produce a fall of resistance, continuing with a higher speed than before the reversal. As coherization goes on, however, the fall of resistance due to reversals becomes less. Later on the resistance will, in the case of a reversal, first augment for a certain interval, to diminish afterward much more slowly, after a maximum has been reached. For a nearly completed coherization, no effect is observed. The same phenomena are observed in the case of brass, though being less marked than in the case of steel. From the above it is inferred that a contact resistance has a character quite different from that of a metallic resistance, being a reversible function of the intensity whenever no variation due to the passage of the current is going on. An irreversible diminution is noted in addition, whenever the resistance is traversed for an appreciable period by a current of sufficient intensity, the latter phenomenon depending on the direction of the current.

SCIENCE NOTES.

V. Henri and A. Mayer find that the radium rays precipitate negative colloids, such as colloidal silver; but are without influence on positive colloids, such as ferric hydrate. Oxyhæmoglobin is transformed by them into met-hæmoglobin and slowly precipitated. Oxycarbonated hæmoglobin is unaffected. The ferments invertin, emulsin, and trypsin gradually lose their activity when exposed to radium rays, and after several day's exposure become quite inert. The red corpuscles of the blood are profoundly affected. Those which have been exposed to radium rays are easily affected by various solutions, giving up their hæmoglobin and salts much more readily than normal corpuscles.—Compt. Rend.

M. E. Pozzi-Escot finds that a solution of molybdic acid or of a molybdate furnishes a very sensitive reagent for tannin, giving, even in very dilute (1: 10,000) solution, a fine orange yellow color with a few drops of a solution of tannin; the reaction is quite evident with a solution containing 1: 100,000 of molybdic acid; after concentration, 1: 1,000,000 may be readily detected. The author has failed to get a similar reaction with other phenolic bodies, except gallic and pyrogallic acids, which give a similar color. The color is not modified by boiling. Most tannin-containing extracts give the reaction, with the exception of logwood, which gives a brown precipitate. The reaction only occurs in neutral solutions, since any free acid interferes with, and in very dilute solutions prevents, the formation of the color. The presence of iron does not interfere with the reaction unless the tannin be in excess. If a drop of the black emulsion be then placed on a piece of white filter paper, as the black iron tannate is deposited, the edges of the drop acquire a yellow tint, due to the tannin molybdate reaction.—Annales de Chim. Analyt.

The new apparatus for taking soundings at sea while the ship is in motion, designed by Eilt T. Jacobs, of Neuharlingsiel, and manufactured by D. Simons, of Kiel, belongs to that type of instrument in which the depth to be measured is deduced from the angle which the plumb line makes with the horizontal. The improvements effected are to meet the common objection raised against such apparatus, that no reliable measurements can be made in a troubled sea, and when the ship is changing its course. The device consists essentially of a skeleton square, built up of rods of equal length, jointed at the four corners. One of the perpendicular sides fits with a ball and socket joint into a stand of ample dimensions; a counterweight is attached to this side, oscillating within the stand. The square will therefore always remain in a vertical plane, no matter how the ship rocks; and it can, moreover, turn about its vertical axis, being thus independent of any change in the direction of the ship. There is another and smaller counterweight in the continuation of the upper bar, to keep the square normally balanced. In that corner is fixed an arc of a circle, a quadrant, to the end of which a cord is attached. This cord is carried around three pulleys, arranged in series. The lead line is taken from the winch to the stand of the device, where it is guided, and along the lower bar, from the end of which it descends into the water. When the lead is being dragged over the bottom, the jointed square will be pulled down, turning into a rhombus, hanging down obliquely. The arc will then project beyond the perpendicular, and the cord coiled round the pulleys will cause a pointer to mark the respective depth on a scale. The sine of the angle is measured, but the actual depths are read off from the scale. The instruments may be convenient for taking continuous soundings—for instance, on cable steamers. They can be combined with electrical contacts which give warning when the limits of safe minimum depths are exceeded. The device is built up of iron rods; the pointer is itself weighted lest it be influenced by the vibrations of the ship.

Vanadium was discovered in 1830 by Sefstroven, a Scandinavian chemist, who obtained the mineral from a specimen of iron ore taken from the mines at Taberg, Sweden. It was subsequently produced in considerable quantity from the slags from the Taberg blast furnaces. Vanadium has a specific gravity of 5.5 and is a light grayish white metal, of silver-white luster. Its reduction from pentoxide to the metallic state is accomplished by heating the oxide in the electric furnace, under the addition of reducing agents. It is insoluble in hydrochloric acid or aqueous alkalies, but is attacked by sulphuric acid and readily dissolved by dilute or concentrated nitric acid. When fused with caustic soda, hydrogen is evolved and sodium vanadate is produced. It is obtained from iron ores containing it by mixing the finely powdered ore with niter and heating the mixture in a fireclay crucible to complete fusion. The cooled mass contains the vanadium compounds in the form of potassium vanadate, which is then treated in boiling water, the solution thus obtained is filtered, nearly neutralized with nitric acid and mixed with a solution of barium chloride or nitrate, to precipitate the insoluble barium vanadate. This is separated from the liquid by filtration, washed with water and decomposed by heating with dilute sulphuric acid. The acid liquid thus resulting is then filtered from the precipitated barium sulphate, neutralized with ammonia, concentrated by evaporation on the water bath and cooled. Solid pieces of ammonium chloride are then introduced into the solution, when ammonium meta-vanadate, soluble in water but insoluble in a concentrated solution of ammonium chloride, gradually separates out after long standing. The vanadate thus formed is then filtered off, washed with a

concentrated solution of ammonium chloride, dried and gently heated in an open crucible. Vanadium is often associated with ores of uranium. Vanadium may be recognized by the yellow color given to the salt of phosphorus bead in the oxidizing flame before the blowpipe. Vanadium pentoxide is worth about $1 per pound, the price having fallen since the discovery of considerable quantities of vanadium with uranium ores in Colorado.—Mining and Scientific Press.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

American Manufactures in Scotland.—American pumps have lost none of the favor in which they have long been held. The trade is well managed. Some makers of these and other American devices have shown good business tact by sending representatives to customers in this country, not to solicit orders but simply to take suggestions as to any improvement or change which might better adapt them to the market. This enterprise of manufacturers is a novel thing to foreign dealers and is warmly commended here. In a few cases alterations have been made in pumps and other articles to meet local wants or fancies, with good results.

Our machine tools and hand tools continue in strong demand. By sending over poor goods a few years ago German firms irreparably injured their tool trade in this market, and they are no longer serious competitors. In the same way German cutlery concerns have failed to retain their hold here, to the great advantage of Sheffield.

In 1901 the Germans had practically all the trade in steel spoons, but this has now been taken by the Americans, who make a better article at as low a price. One Edinburgh wholesale house is doing a profitable business in these spoons, which are sold principally in the country districts.

In a variety of electric fittings, and also lamps for incandescent gaslighting of streets and parks, the Germans are offering satisfactory goods at much below American or English prices and are therefore getting an extensive trade.

A Scottish wholesale firm has scored a decided commercial "hit" with an American machine-made, single-barreled, breechloading gun, which sells at a moderate price.

Galvanized goods, such as oil cans, are selling freely; the Americans have a share of this trade, and, in the opinion of prominent dealers, will obtain more of it if they keep their wares up to the present standard.

Apparently, we are not competing successfully with the Canadians in the churn trade, but in wood goods generally we are much ahead of them. Our supplies for beekeepers are always in demand. American handles, as well as forks, have been advanced in price for next season, yet the usual large orders are probable. "We cannot do without them," said a dealer to me.

Our wood-working machinery—for planing, sawing, molding, sandpapering, etc.—has long been used in Scotland to a considerable extent. German machinery of this kind has been pushed of late in a very energetic way, and our makers and exporters must be keenly on the alert if they would lose no opportunities here.

Canadians are dividing with Americans the trade in imported lawn mowers in this part of Scotland.

There is an increasing sale of American clocks and watches of standard quality and moderate prices.

Scotland has been taking a large amount of general hardware, including enameled ware, from Germany.

Ship chandlers are handling fair quantities of American valves, ironware, and other supplies. This trade has been growing and promises to become important if the right methods are pursued. I am informed by one firm that in some instances the packing of these goods has been "grossly defective."

In furniture, roll-top desks and bookcases are still the prominent items in the imports from the United States. The desks are sold largely, notwithstanding that the local office furniture manufacturers have copied them closely and made special efforts to keep out the foreign article.

Dealers in American shoes report an increasing trade. Our styles gain popularity and prices of the best grades are low compared with the prices people heretofore paid for home manufactured shoes. A notable effect of the American "invasion" in this branch of trade is a general reduction of the extraordinary profits of retail dealers before the introduction of American stores. Grades of British made shoes which sold for $6 four years ago can now be bought for $4.

Our leather, both sole and upper, has been imported in somewhat larger quantities than last year by British shoe manufacturers, owing, it is said, to their increasing orders from the colonies. Not only is the British shoe made chiefly of American leather and by American machinery, but even the metal hooks and eyelets are practically all imported from the United States.

Our axes, heavy and light, are still prime favorites; neither British nor continental makers can equal them in the combined merits of excellent quality and cheapness.

American carpet sweepers have long been in this market, but the possibilities of this trade will hardly be realized except by a house-to-house canvass by energetic salesmen.

Although our paints and varnishes are yet a small commercial item, there is a promising increase of sales. Some dealers are much pleased with the American varnishes they have been getting, as the reports from coach builders and others are highly favorable.

Our soaps, toilet and common, are used more than ever. The enterprise of American manufacturers of the better grades is notable, both in the methods of placing their goods on the market and of advertising them, and it is thought that the business will develop greatly in the near future.

American computing scales, cash registers, and other specialties have been widely sold in Scotland this year, and the agents say that there is yet a very broad field before them.

A distinct gain has been made here by our manufacturing chemists in many articles in common use and by our exporters of a variety of small goods, chiefly novelties, handled by jobbing houses. The market for novelties of every description is inviting, and success in this line depends only on putting the goods in the right hands.

German exporters of textiles have developed in this country a trade of some importance in woolen underwear.

The imported nails are principally from Germany, as are also moldings. It is needless to say that toys are mostly German, but this year many have been coming from the United States.

Our wooden ware is extending slowly and steadily, and it seems certain that if well managed this trade will attain great dimensions in a few years.—Rufus Fleming, Consul at Edinburgh, Scotland.

Opportunities for American Trade in Austria.—I am satisfied that many of our products could be sold in Austria if a systematic effort were ever made to introduce them.

Tools and farming implements.—Tools of all kinds, as well as farming implements, are dear, clumsy, and old-fashioned in this part of Austria. Plows, especially, are far behind the times. A wideawake farmer now and then imports an American plow, but a regular depot for such ware does not exist anywhere in southern Austria.

Furniture.—Austrian furniture is expensive and, in many respects, greatly inferior to ours. American folding beds and office furniture, roll-top desks especially, could, in my opinion, be sold here without any difficulty.

Food products.—American cheese, cornmeal, oatmeal, and our various breakfast foods should be brought to the notice of the Austrian consumer. Our canned goods are already sold here as luxuries and would no doubt find a much readier sale were it not for the high Austrian import duty on such goods, which is about 10 cents a pound.

Stationery.—American stationery is being more and more appreciated in Europe. Austria exports a large quantity of paper, but really good letter paper is exceedingly scarce here. Pens, pencils, and erasers of Austrian manufacture are likewise inferior.

Boots and shoes.—There is an opening for American shoe stores in southern Austria. The home made article is cheap, but of poor quality, and cannot compare with the American product in style, fit, or comfort, and there is consequently a growing demand for our shoes among the better classes. In view of this, I am of the opinion that the establishment of an American shoe house with both wholesale and retail departments, to be managed by an American on American principles, would prove a most lucrative investment.

Miscellaneous goods.—Other American goods, as carriages, safes, gas fixtures, typewriters, and engineering implements and supplies, could be sold here more extensively than they are sold at present if their sale were pushed.

How to build up trade.—Our manufacturers and exporters cannot be told too often that flooding the continent of Europe with English circulars and catalogues is wasting time and money, and that the surest, and, in the long run, the cheapest way to increase their exports is to send out competent and reliable salesmen familiar with the languages and customs of the countries in which they are expected to do business.

British manufacturers keep an army of agents abroad for the enlargement of their trade. Our manufacturers, as a rule, enter the foreign market only when business is slack and prices are low at home, and abandon it as soon as business commences to improve at home. Staple products have always been sold successfully in this fashion, probably because they are bought on their grading, and men who buy and sell at the produce exchange are, as a rule, neither overconservative nor oversentimental. But manufactured goods are largely bought on faith. Faith grows slowly and withers easily, and it is exceedingly doubtful whether the foreign dealer, who was once persuaded into purchasing American goods when trade was dull in the United States and coolly ignored when trade picked up again, will care about renewing such commercial relations. Whether business is flush or dull at home the European manufacturer never neglects the foreign market. Whatever demand there may be for his wares at home, he will try hard to fill the orders of his regular "correspondents" abroad, and if the exigencies of the foreign market at times demand even the sacrifice of reasonable profits, he makes this sacrifice and charges it to insurance against hard times. If American foreign trade is to have a healthy growth United States manufacturers must learn a lesson from their German and British competitors and cultivate it in all kinds of weather.—Frederick W. Hossfeld, Consul at Trieste, Austria.

Opening for American Tin Plate in France.—It is believed here that the time is now opportune for introducing American tin plate into France. There are two manufactories of tin plate at Nantes and they are both prosperous. One of them, though belonging entirely to French owners, is in the hands of British operatives. British methods of manufacture are almost exclusively followed in both factories.

This year, in spite of the high tariff duty ($2.70 per 220 pounds) and in spite of the decreased demand for tin plate, on account of the failure of the sardine catch, British tin plate exporters have managed to sell considerable quantities of tin in this market. They are governed by French prices, which they follow very closely, or, if they undersell the local manufacturers, the difference is very small. There is a popular idea that the British product is better than the French and this helps the British exporters. In any event there is a large and constant demand in western France for tin plate, and here in Nantes the consumption for the manufacture of cans and boxes used in the preservation of fish, vegetables, and other alimentary products is enormous. If the matter interests any of our tin plate manufacturers I can furnish the name of an energetic and reliable Frenchman who would like very much to enter into relation with some of them. Tin plate could be shipped to Nantes either via Havre, Bordeaux, or Antwerp; and it would be easy to ascertain in New York the cost of transportation. As stated above, the customs duty is $2.70 per 220 pounds, and there are no other entry charges of any importance.—From United States Consul Ridgely, Nantes, France.

American Goods on the Amazon.—Within the past ninety days a large number of ready-made cottages reached this port from New York, and I am informed that many more of them are on the way. These will be erected on ranches and rubber estates, and if they prove satisfactory a very large demand for them will be immediately created.

American vapor and kerosene launches are rapidly winning favor here. An order for ten small launches goes forward by the steamer which bears this report. The kerosene motor has the call here, though both are in demand.

American ice-making machinery has a complete monopoly of the Amazon from Iquitos, Peru, to Para—3,500 miles—and the business is a very important and lucrative one in this burning climate. Bolonha & Paiva, a Para firm, control this enormous field and are rapidly supplying all the smaller towns and large private estates with the latest American ice machines. They have an agent now in the United States executing orders.

The Amazon Steamship Company will add ten steamers to its fleet on September 1 to accommodate the increasing trade between Para and upriver points.

The States of Amazonas and Para have contracted with a private company for the use of the Marconi system in their respective territories, and each of these States has granted a subsidy of 150 contos, equal to about $37,500 and aggregating about $75,000, for 15 stations. Any stations necessary beyond this number are to be paid for above this amount of subsidy. The Federal government has granted permission for the necessary experiments, stations, etc. I am informed that the company will be organized and financed in the United States.

The ever-widening inducements offered by the vast Amazon Valley to capitalists, its continued and rapid development, enticing business opportunities, commercial field, natural wealth, and growth are so large that it is rather difficult to fully comprehend it.

As an inducement to desirable immigrants free land grants can be obtained here for the asking.—K. K. Kenneday, Consul at Para, Brazil.

Steamboats Wanted in Paraguay.—United States Consul J. N. Ruffin, of Asuncion, under date of February 23, 1904, reports as follows:

One of the departments of the Paraguayan government has made a specific inquiry with a view to purchasing suitable boats for the River Plata. It desires information at the earliest possible date. The steamers should be of 400 or more tons capacity, in good condition, and with a draft not exceeding 7½ feet loaded. Their average speed should be about 12 miles an hour, with a daily coal consumption of 4 tons. The cargo will consist principally of cotton. Price and time of delivery should be stated. I am unable to give an exact description of what the people here desire, but they will consider proposals for any good, sound boat, economical and suitable for navigation of these waters.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

Other Reports can be obtained by applying to the Department of Commerce and Labor, Washington, D. C.

ENGINEERING NOTES.

A test has been made on the Berlin-Zossen military railroad of a steam locomotive of the 4—4—0 type, weighing 120,000 pounds in working order, and fitted with a Schmidt superheater. The cylinders are 20¾ inches diameter, drivers 78 inches diameter, and working pressure 170 pounds per square inch. With a train of six cars weighing 224 long tons, the engine attained a maximum speed of 79½ miles an hour and an average speed of 57 miles an hour. The maximum speed was reached 9½ minutes after starting. The entire run was made in 15 minutes. With three coaches, the maximum speed was 84 miles an hour, and the run was made in 13 minutes at an average speed of 65.8 miles an hour. Six minutes after starting the speed was 74½ miles an hour. A maximum indicated horse-power of 1,800 was developed. The train resistance at 79½ miles an hour is about 25 pounds per ton, so that the power actually developed is 1,187. In other words, the power required to overcome head-end air resistance, machine friction, rolling friction, etc., of the locomotive is 1,800 — 1,187 = 613 horse-power, or about 34 per cent of the total power developed by the cylinders. This illustrates one reason why high-speed service is expensive. It is said that no dangerous vibrations were set up in the locomotive at the high speeds, but for easy riding it is important to maintain a total wheel base of 17 feet.

A huge engineering undertaking is shortly to be commenced by Russia—the construction of a navigable canal from Riga in the Baltic Sea to Kherson in the Black Sea, a distance of 800 miles as the crow flies. The designs for this great waterway have been prepared by the eminent Russian civil engineer Ruckteschell. Although the distance in a straight line between Riga and Kherson is only 800 miles, the canal will have to be 1,468 miles in length. There is already a more or less efficient water communication between these two points in existence. In the province of Smolensk, 350 miles southeast of Riga and 600 north of Kherson, two rivers have their sources in the same marshes—the Dnieper and the Duna respectively. The former follows a meandering course for 1,330 miles and empties into the Black Sea near Kherson. The other flows more directly to the Gulf of Riga, being only 577 miles long, and the town of Riga is situated at its mouth. These two great rivers are connected by the Berezina canals, by means of which the Berezina stream, a tributary of the Duna, is thereby rendered navigable for rafts and barges. This connecting waterway, however, will have to be considerably improved to render it of any commercial utility and value. The canal is to be 266 feet wide at surface, the banks tapering inward to a width of 140 feet at the bottom; the depth is to be 31½ feet. A broad paved road will be built by the side of the canal throughout its entire length, and thus there will not only be a canal traversing the country from north to south, but a roadway also. By means of this waterway a great stimulus would be imparted to Russia's over-sea traffic, as it will afford a new highroad from the Baltic to the Mediterranean, while it will also be of great strategical importance. The project, it is estimated, will involve an expenditure of $180,000,000 to complete.

It is not an uncommon thing — this age of advancement in industrial and engineering matters for the present-day engineer to assume that he knows much more than his ancient brother, and while this is true in many things, it frequently happens that an invention or appliance commonly believed to belong to modern times is found to have been known and used centuries ago. Ropes made of various kinds of fiber and leather are of very ancient date. Ropes of palm have been found in Egypt in the tombs of Beni-Hassan (about 3000 B. C.), and on the walls of these tombs is also shown the process of preparing hemp. In a tomb at Thebes of the time of Thothmes III. (about 1600 B. C.) is a group representing the process of twisting thongs of leather and the method of cutting leather into thongs. The Bible tells us that Samson was bound with ropes and that the spies sent by Joshua into Jericho were let down in a basket, presumably by means of a rope. At Nimrud, Assyria, a carved slab showing the siege of a castle was found, on which a soldier was represented in the act of cutting a rope to which a bucket for drawing water from a well outside the castle walls was attached. The wire rope is generally considered a modern invention, a product of modern skill, and it will surprise many to learn that its manufacture is really a rediscovered lost art. Although the Assyrians practised the art of wire-beating, no evidence has been found to indicate that they used wire for making rope. The excavations at Pompeii have, however, brought to light a piece of bronze wire rope nearly 15 feet long and about 1 inch in circumference. This rope is now in the Museo Borbonico at Naples. It consists of three strands laid spirally together, each strand being made up of fifteen wires twisted together and its construction does not, therefore, differ greatly from that of wire ropes made to-day. Pompeii was buried A. D. 79, 1,825 years ago, but how long wire ropes had been known it is impossible to tell, though, judging by the knowledge shown in the construction, it may be safely concluded that they had been known for a considerable time. The use to which these ropes were put is not definitely known, but further excavations may shed some light on the subject. As to the use of rope tramways, it is said that they were in use as early as 1644.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents and canvassers.

MUNN & CO., Publishers, 361 Broadway, New York.

TABLE OF CONTENTS.